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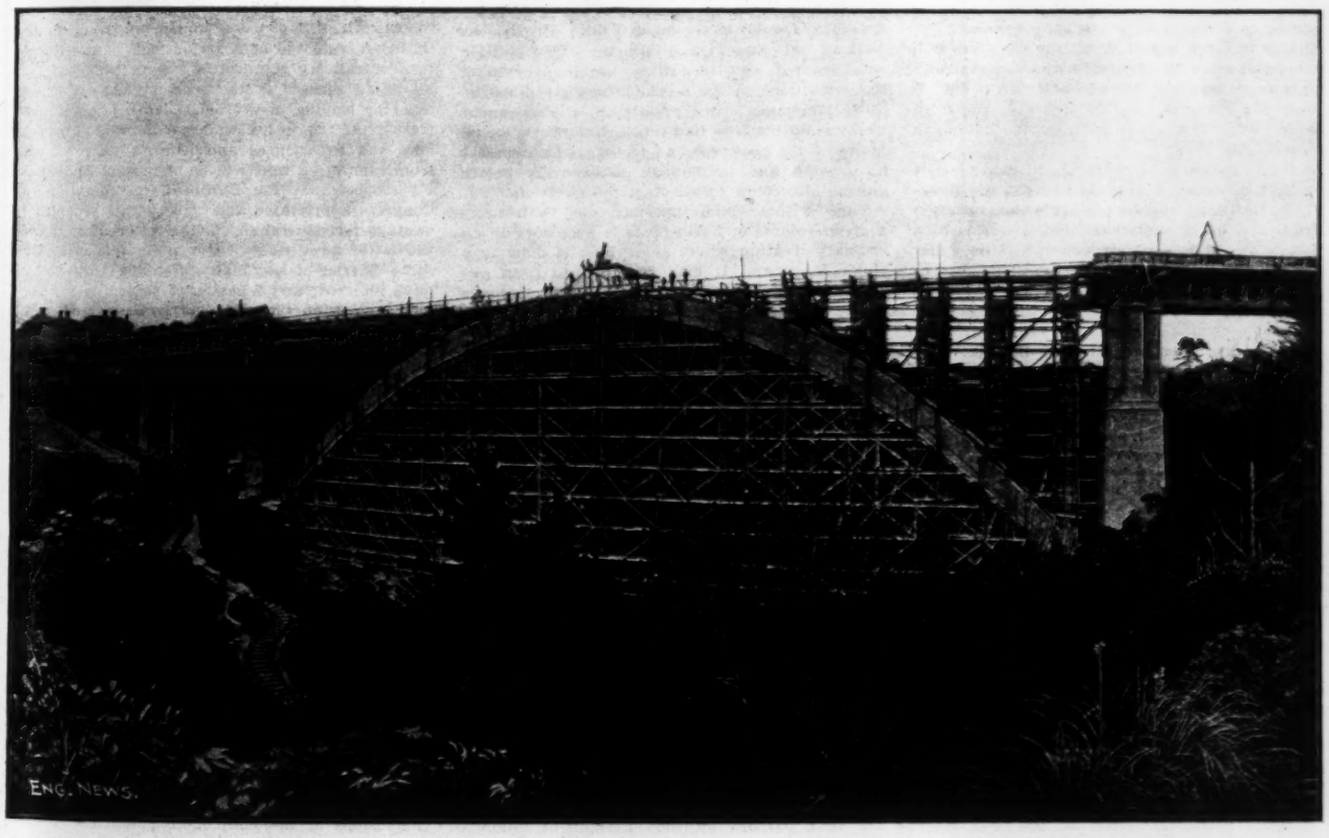
The 320-Ft. Reinforced-Concrete Three-Hinged Arch of the Grafton Bridge, Auckland, N. Z.

The Grafton Bridge across Cemetery Gully at Auckland, New Zealand, a reinforced-concrete structure of considerable size containing as its middle span the largest masonry arch now in existence, was opened for traffic April 28, 1910. This is a highway bridge built by the city of Auckland to connect two portions of the two separated by a deep gully and connected hitherto only by a weak, narrow suspension bridge. Bids were asked for the new bridge some years ago and among the designs submitted was one by the Ferro-Concrete Co. of Australia, Ltd., through its then Chief Engineer, Mr. B. F. Moore. With some few changes this design was accepted and the work carried out by the company under Mr. Moore's supervision.

The bridge consists of an approach on one side of six spans varying from 35 to 81 ft., the central arch of 320-ft. span and three approach spans on the other side varying from 43 to 81 ft., a total length, including the piers, of 960 ft. With the exception of the middle arch all of the spans are of reinforced-concrete girders, three of them solid girders and six of open panel construction such as is shown in Fig. 2. The mid-span is a 320-ft. reinforced-concrete three-hinged arch composed of two separate ribs separated by cross struts and carrying the floor on slender columns. The width of the bridge is 36 ft., made up of a 24-ft. roadway and two 6-ft. sidewalks.

Above is a view of the main arch under construction showing clearly the immense amount of lumber used in the falsework, upwards of 400,000 ft. B. M., it is reported.

The bridge was designed by Mr. Moore, as noted above, with Mr. W. E. Bush, City Engineer of Auckland, acting as engineer for the city. The contract cost was about £33,700 ($163,000), and the land, engineering, etc., brought the total cost up to £39,000 ($188,000).



THE GRAFTON BRIDGE, AUCKLAND, N. Z., TAKEN DURING THE CONSTRUCTION OF THE 320-FT. MAIN ARCH.

Some Impressions of The International Railway Congress.

(Editorial Correspondence.)

The International Railway Congress which met in Washington five years ago has just concluded a meeting at Berne, Switzerland. The Congress continued from July 4 to July 16 and was attended by hundreds of delegates from all over the world, including delegates from the United States.

This is not a report of the Congress's technical work. An exhaustive report of that would be too exhaustive for the reader to say nothing of the writer. The printed papers and reports which were presented at the Congress make a stack of octavo pamphlets 8 ins. high. The Congress met

in five separate sections which held sessions morning and afternoon on seven different days. Any compunctions of conscience which I might feel for not presenting to the readers of Engineering News a complete report of the discussions in these sessions are mitigated by the fact that the editors of technical journals, while formally invited to attend the Congress and welcomed to the social festivities and the general sessions, were also formally invited not to attend the meetings of the separate sections. The best reason I have been able to discover for this negative invitation is that it relieved the aforesaid editors from attempting to accomplish an impossible task.

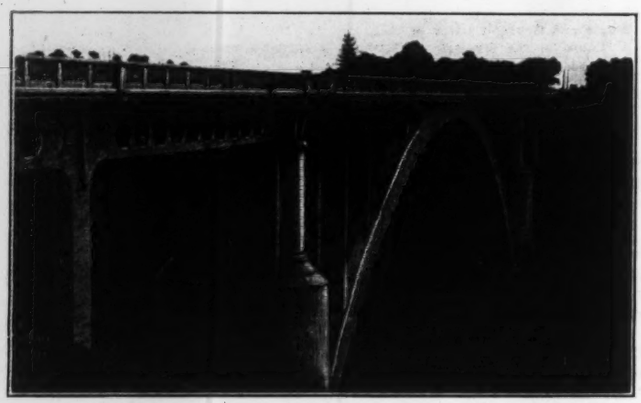


FIG. 2. THE COMPLETED GRAFTON BRIDGE AT AUCKLAND, N. Z.

So this is not a report of all the Congress did, nor even of what the fifty odd American railway officers (and near officers) who attended it did. It is only some impressions, to give the reader an idea of what this great International Railway Congress was like.

And first (since many have short memories) it may be well to say a word as to what the International Railway Congress is. It is an association of railways in all countries of the world, both railways owned by corporations and those under national ownership. The companies or governments not owning railways may appoint delegates to the Congress. Besides these, governments now owning railways may appoint delegates who are usually connected in some way with railway administration. Thus two of the government delegates from the United States were Messrs. Lane and Clark, of the Interstate Commerce Commission. The official list shows 325 members of the Congress in the United States, and by no means all of the railway companies of the United States hold membership in the Congress. In fact, although the Congress was organized and held its first meeting 25 years ago, American railways took little interest in it until the Paris meeting, in 1900. Interest in America was greatly stimulated, of course, by the meeting in Washington five years ago.

The dues for membership in the Congress are moderate. Railway companies which are members pay dues which are fixed at $20 per annum plus a sum proportioned to the mileage of the system and can appoint such of their officers as they choose as delegates, who will thus receive the published papers, reports and proceedings of the Congress whether they attend the sessions or not. Anyone, however, whether a railway officer or not, may subscribe to the official journal, a monthly periodical issued by the "Permanent Commission" which controls the affairs of the Congress and has its headquarters at Brussels, Belgium.

But turning now to the recent Congress at Berne, I think the strongest impression made on an American was: What a great barrier difference in language constitutes! I suspect most Americans, dropped for the first time into the polyglot confusion of such a Congress as this, have the sensations felt by the proverbial cat in a strange garret. Perhaps in even greater degree, for I can testify that the cats of many nations have a common language.

Americans feel this language barrier more than the men of any other nation, because we are the most deficient in knowledge of other tongues than our own. We are worse even than the English in this and we are less accustomed than the English to life where other languages than our own prevail.

The American delegates to the Berne Congress were no exception to the general rule. Most of them had acquired enough of the common or menu card French and German to supply themselves with three meals a day and not guess at more than half the constituents. But to sit in the Congress and listen to the addresses and discussions delivered in French or German or something worse and comprehend what it is all about, is a task at which most of the American delegates (with a few highly honored exceptions) were completely floored.

And it may here be recorded that after two or three days of sitting through the sessions of the Berne Congress and understanding little or nothing of the discussions, the English and American delegates joined in a petition to the "Permanent Commission" that for the remaining sessions, the speeches should be translated into English as well as into French and German. This petition was granted and thereafter nearly everything that was done in the sessions was given in the three languages. Accordingly, if a Frenchman made some remarks in French, the official translators of the Congress had to repeat his remarks in German and in English successively before anyone else could speak upon the question.

Thus it took three times as long to transact a given volume of business as is necessary in an ordinary meeting where everything is done in a single language. It may be imagined from this how dull and sleepy these long sessions, six hours daily, were. It is often very difficult to hold the attendance and the interest in a technical meeting where everything is in one language. Imagine then the difficulty of holding the attention of an audience where two-thirds of the time is taken up with talk unintelligible to the listeners.

Small wonder, therefore, that many of the delegates found the incomparable scenery of Switzerland more attractive than the Congress sessions. Yet it should be said also that a goodly proportion of the delegates were industrious and persevering in their attendance. And in the proceedings the Americans took a large part in proportion to their numbers compared with the delegates of other nations.

And now what are these proceedings? As stated above, the Congress did most of its work in the separate sections. These were devoted respectively to: I., Way and Works; II., Locomotives and Rolling Stocks; III., Working; IV., General; V., Light Railways. In each of these sections, papers were presented by railway officers of different countries on various questions set for consideration. The author of a paper is called a "reporter" and is supposed to report the practice in the field covered by his paper, being appointed for that purpose by the "Permanent Commission."

These papers, printed in advance and distributed to the members, were supposed to be presented as brief abstract only; but often much time was consumed in their presentation. Then came the discussion, carried on in three languages, as already explained. Finally, an attempt was made to crystallize the reports and discussions on a given subject in "conclusions," and much time and effort were spent in arriving at the exact wording of these "conclusions."

Now while in theory these official "conclusions" represent the sum of the Congress's achievements, it is my impression that they are [illegible] the lamest, the most impotent and actually the most unimportant feature of the whole Congress. One clear-sighted American delegate remarked that the "conclusions" reminded him of the Gilbert & Sullivan opera where

> You are right and I am right, and everything is quite correct.

Nearly all the conclusions read substantially as follows:

> That the practice described in the report is interesting and deserving of attention; and railways so located that they can adopt it to advantage should do so and those who cannot should continue their present practice.

Now, as a matter of fact, it would be impossible to draft conclusions applicable to all the railways of the world with all their vast differences of condition and circumstances and employ any other terms. I do not know of any detail of practice in track or rolling stock or traffic developed during the first quarter century, so excellent and so broadly applicable that it could be recommended officially for adoption to all the railways of the world.

I set it down as my impression, therefore, that the "conclusions" of the International Railway Congress, which are quoted with profound respect, really represent so little of importance in the way of definite statement that they might as well be ignored.

But, it may be asked, what then does the Congress amount to? What does it really accomplish "to promote the progress and development of railways"—to quote from the Constitution of the Congress?

My impression is that it accomplishes two things. In the first place some of the papers and reports which it procures and prints rank among the most valuable of contributions to the literature of railway engineering, using that term in its broad sense. In the second place, it brings together leading men from the railway administrations of the world, who can interchange opinions and experiences and learn a vast amount from each other that will be of mutual benefit.

I suspect that the European members of the Congress appreciated and utilized this second advantage far more than did the Americans, taking the latter as a whole. One main reason is this same barrier-of-language difference to which I have referred; and I hasten to record as my second impression that this barrier is not after all so great as the American generally thinks. The average American when he attends an International Congress, and cannot speak or understand a foreign language, consorts with other Americans in the same boat or perhaps with a party of Englishmen. He does not attempt to talk with delegates from France or Germany or Austria, because he takes it for granted that they are as ignorant of his language as he is of theirs.

My experience is that this is a mistake. A very large proportion of the foreign delegates to such a Congress as this have more or less command of English, enough usually for ordinary conversation. The American delegate who, instead of spending his time with men whom he might meet any day at home, will take the pains to become acquainted with the Europeans who are engaged in similar work to his own, will have in most cases his social horizon extended, and his ideas broadened to an extent possible in no other way.

The barrier of language, as I have just said, is undoubtedly an enormous handicap to the formal proceedings of the Congress. It robs the sessions of life and interest and helps to make the formal conclusions of the body mere platitudes; but it does not prevent many of the great minds of different nations assembled together from learning much from each other, despite differences in the mother tongue.

Of course this is perfectly well known to the Europeans, particularly those from the Continent. Imagine that the great magnet that draws to this Congress so many leading railway officers from France and Germany and Russia and other of these continental nations is the opportunity of meeting the railway officers of other countries than their own for mutual conference and exchange of ideas quite outside the formal meet-

ings of the Congress. This is one reason why the Railway Congress means so much more to the continental Europeans than it does to us in America. The fact is, too, that these Europeans from different countries are no strangers to each other. They have to meet to arrange matters where international traffic is concerned. Their railway methods are sufficiently similar to make interchange of experience particularly valuable. We cannot expect that the International Railway Congress can possibly do for our railways at home what it has done for European railways; but let me again record my impression that it can do enough for us to be very well worth while for our railway officers to take part in it.

And my impression is further that the Americans who attended the Berne Congress felt that their time had been well spent. And not only well spent but pleasantly spent.

One of the strongest impressions made on me was the hospitality of the Swiss Government and the Swiss people and the admirable manner in which that hospitality was exercised. It was a big thing to do. Switzerland is a little nation. All told it has less area, population and wealth than any one of several of our states. I do not know of any American state, however, which could assume the task of taking care for two weeks of such a Congress as this, attended by over 1,500 people, from all the nations of the world, and could in any way rival the success attained by the Swiss nation as a host.

I am not alone in this impression. The name of E. L. Corthell is familiar to a large proportion of Engineering News readers. He is one of our few American-cosmopolitan engineers, having headquarters and carrying on professional work in at least three different continents. Incidentally, Mr. Corthell has had much to do with the organization and management of more than one International Congress. On the concluding day of the Congress, Mr. Corthell (who was an accredited delegate from the United States) told me he had never seen, in all his experience, an International Congress so admirably organized and managed by those in charge locally of the reception and entertainment.

A catalog of the various excursions and entertainments which were given for the visitors during the Congress would be a long one and could in no way give the reader an adequate idea of what we who attended the Congress enjoyed. It ought to be set down, however, that on these occasions the visitors were treated to many surprises where care, thought and money had been expended to add in some way to the visitors' pleasure. There was an attention to detail and a fine taste in the matter of arrangement that bespoke a high artistic sense.

But the impressive thing to me in connection with this hospitality was the fact that the Swiss nation really constituted itself the host of the Congress. The headquarters were located and the sessions were held in the National Capital building, the Swiss parliament chamber itself being used for holding many of the sessions. The President of Switzerland himself took an active interest in the Congress, even going with the delegates on some of the excursions entirely alone and unattended, an example of democratic simplicity which we can admire if we cannot imitate. And the closing social event of the Congress was a dinner given by the President to the delegates, at which a thousand covers were laid.

Besides all of the excursions and social occasions which the delegates enjoyed, every delegate was given a first-class free pass good from June 15 to Aug. 15 over all the railways of Switzerland which are owned by the Federal Government, and the same courtesy was extended to his wife and daughters travelling with him. If there is a country in the world where railway travel is more enjoyable to the lover of natural scenery than Switzerland, I do not know where it is.

This is a mere suggestion of some of the things which Switzerland did for the railway men who were its guests. I am sure that the Americans who had the good fortune to be numbered among these guests will long remember their sojourn there as one of the pleasantest experiences of their lives.

C. W. B.

Zermatt, Switzerland, July 18, 1910.

Petrolithic and Other Systems of Road and Street Improvements at El Paso, Tex.

Considerable discussion regarding the merits and demerits of the so-called petrolithic system of road construction, some of our readers will remember, appeared in Engineering News some months ago (see particularly July 29, Sept. 23, Oct. 14 and 21, Nov. 4 and 11, 1909); also see April 4, 1907, for a general descriptive article on the petrolithic system and tamping roller). A considerable part of this discussion related to or was prompted by comments made by Mr. J. L. Campbell, M. Am. Soc. C. E., of El Paso, on the petrolithic roads in that city. We have recently received from Mr. Parker N. Cole, President of the Barron & Cole Co., New York City (agents for petrolithic road machinery), a letter referring to the afore-mentioned discussions of petrolithic roads and enclosing a copy of a report by Mr. F. H. Todd, Am. Soc. C. E., City Engineer of El Paso, for the year ending Feb. 1, 1910. Inasmuch as Mr. Todd's report contains a considerable amount of interesting information on city paving and road improvement in general, we give some extracts from it. These extracts include statements regarding "petrolithic and oiled macadam."

First of all, we call attention to the accompanying table which summarizes the yardage of pavements of various kinds, including macadam, on Feb. 1, 1909, and Feb. 1, 1910. We have added to the table a column of mileages taken from another portion of the report.

On the general subject of pavement and on some of the local paving complications in El Paso Mr. Todd says:

> Municipalities generally are searching for a kind of street surface which is smooth, sanitary, noiseless and dustless; that is hard and durable, though not slippery, and is easy to clean, patch or renew, as well as low in first cost and maintenance charges. Until such a pavement is found, that one now known to have the especial qualities most demanded in the case in point should be the one selected, and a most searching examination and thorough study of the requirements of each street should be made to find out just what qualities are the ones most needed.
>
> So far in this city the property owners on the street to be paved, ably assisted by the promoters for the various kinds of pavement, have taken the burden of making the selection from the city officials, and I hope that all the selections show the wisdom of the selection made.
>
> To pave a strictly residence street with brick or Belgian block, or even a street where most of the buildings were used for offices, though the wearing qualities of such a pavement were of the best, and its durability of the highest order [is a questionable procedure since noise is more of a factor than durability] in determining the real value of the pavement in this case.
>
> Quite a variety of pavements are in use in the city, as the following list shows: Cobble stone with sand filler; cobble stone with concrete floor; brick with sand filler; bitulithic; asphaltite; petrolithic; oiled macadam; asphalt macadam; macadam telford; macadam with caliche binder.
>
> The cobble stone has been used as a pavement for the alleys in improvement district No. 1, and although they serve the purpose of keeping the wagons up out of the mud, and the mud from the adjoining streets, yet I believe if a sheet pavement was put over these cobbles and the alleys cleaned as often as the streets, it would pay as a sanitary matter, leaving the appearance and convenience as net gain. The cobble with joints filled with Portland cement concrete has served a good purpose as a waterproof covering and waterway, yet it is very noisy, though later it would make a good foundation for some form of sheet paving if the surface of the cobble stone was so placed as to permit this in regard to the grades of the adjoining streets.
>
> No brick pavement has been added during the past year, and the two blocks on South Santa Fe St. are beginning to show signs of wear, though not to an extent to require repairs.
>
> The largest area of street paving is of bitulithic, and this form of pavement continues to give excellent service. The construction during the past season, except on steep grades, has been provided with Portland cement concrete gutters, and these are giving better satisfaction than [gutters in?] improvement district No. 1, where the grades are very flat.

Mr. Todd next takes up what he terms "petrolithic and oiled macadam." In view of the fact that the streets thus improved have been much commented on during the year, he states that he will review the subject, and proceeds as follows:

> On Feb. 1, 1909, there were a little less than 8,000 sq. yds. of petrolithic pavement in this city, and this pavement, being on strictly residence streets, and subject from the first to very light traffic, is in much better condition on the first day of February, 1910, than it was a year ago, and that, too, without any repairs, except where the various public utilities have broken into it. During the year past, there has been laid in this city 68,710.9 sq. yds. of petrolithic and oiled macadam.
>
> The petrolithic paving on Wyoming St., from Williams St. to North Oregon St., is in very good condition, and with some slight repairs, which will be made by the Petrolithic & Construction Co. under their guarantee just as soon as the weather is warm enough to justify, will put this street in an excellent condition. [Parts of three named streets] have also been paved with petrolithic pavement. Portions of this pavement show that too much oil was used in the construction, but I believe that the natural evaporation of the volatile portion of the oil and the slight addition of stone screenings will make this one of our most desirable pavements for residence streets. These repairs, which will be made under their guarantee, are comparatively slight, and will be made as soon as the weather is warm enough to do the work well. A strip 25 ft. in width along [certain named] streets was put in by the county of El Paso, making this the county road, and it has, consequently, nearly all of the heavy traffic of the upper valley, including the cement plant, smelter and flour mill.
>
> The Petrolithic & Construction Co., at the request of this department, and in order to provide a roadway on South Santa Fe St. for the celebration of the meeting of the presidents of the two republics, put in a cheap form of oiled macadam. This oiled macadam consisted of from 2 to 3 ins. of broken stone on a caliche base, and 1 gal. of oil per sq. yd., on which was placed screenings enough to fill the voids; this form of construction, while it holds up the traffic and has shown no signs of breaking through, yet it did not have oil enough, and a further application of oil and screenings will be necessary to preserve it and prevent raveling. In this construction, I think we have learned that a very good road surface can be made on the caliche streets, by using not to exceed 3 ins. in thickness of graded crushed rock and not less than 1½ gals. of asphaltic oil per sq. yd.
>
> While this construction was done for 30 cts. per sq. yd., I am doubtful of being able to build a street surface for any less than 40 cts., and it will probably cost as much as 45 cts. per sq. yd., exclusive of the caliche base.
>
> An oiled macadam pavement was also constructed on [parts of] West Boulevard and on West Main St.; crushed rock on these streets is from 5 to 8 ins. in thickness, and, so far, they are not particularly satisfactory; several reasons have been given for this, and the most probable seems to be that they were put down in cold weather with insufficient oil.
>
> A great deal of experimenting is being done throughout the country in an honest endeavor to provide a bituminous street surface which will serve many of the purposes of an ideal roadway, and at the same time be cheap.

TABLE SHOWING AMOUNTS OF VARIOUS KINDS OF PAVEMENT IN PLACE IN EL PASO, TEX., ON FEB. 1, 1909 AND FEB. 1, 1910.

Kind.	Square yards			Miles
	Feb. 1, 1909.	Built 1909.	Feb. 1, 1910.	Feb. 1, 1910.
Bitulithic	129,294.04	154,557.77	283,851.81	9.59
Petrolithic and oiled macadam	7,773.90	60,937.00	68,710.90	3.20*
Asphaltite	.....	7,218.00	7,218.00	.28
Telford macadam, caliche binder	.....	22,800.00	22,800.00	.78
Asphalt macadam	.....	9,166.67	9,166.67	.70
Straight macadam	36,500.00	.....	36,500.00	1.03
Brick	5,106.00	.....	5,106.00	.10
Cobble stone	14,620.82†	.....	14,620.92†	1.15†
Total amount of pavement	193,294.86	254,679.44	447,974.30	16.83

*2.75 miles of petrolithic and 0.45-mile of oiled macadam.
†Of the cobble stone, 3,377 sq. yds. are on one street and the remainder is all in alleys.
GENERAL NOTE.—The total street mileage is 153, of which 16.83 are classed as paved; 94.70 as "passable" and 30.70 as "graded."

Reinforced-Concrete Grain Bins for the Storage Annex at Superior, Wis., Great Northern Ry.

By O. B. ROBBINS.*

In the winter of 1907-8, a large wooden elevator, part of the terminal system of the Great Northern Ry. at Superior, Wis., was destroyed by fire. To replace the storage capacity thus lost, as well as to care for the normal increase of the grain shipments, it was determined to build a fireproof storage house of approximately 2,400,000 bushels capacity. It was decided to make this new storage house essentially an extension of the large steel working house, of over 3,000,000 bushels capacity, which was constructed in 1900.

The steel house, known as Elevator S, may be considered, as far as the handling of grain is concerned, as consisting essentially of nine separate receiving and shipping units under one roof. Each unit has its receiving hoppers, elevating belt, scales for weighing incoming and outgoing grain, shipping belt and spouts. Longitudinal conveyors connect these units to give flexibility to the system, by transferring grain from unit to unit. With all the units in operation, Elevator S has a receiving capacity of over 30,000 bushels per hour out of cars, and a continuous shipping capacity of 90,000 bushels per hour into boats.

In the construction of the storage annex it was determined to extend the unit system of S in the arrangement of the storage bins. Consequently each of the eight south units of the old Elevator S has built tributary to it eight circular bins and six interspace bins (Fig. 1). The north unit connects with eight circular bins and three interspace bins. The storage units thus formed have no connection with each other, except through the longitudinal conveyors and a partial system of cross-spouting in Elevator S.

The general dimensions of the storage house were fixed within narrow limits by the width of the available land and the necessity of connecting to the steel house. The bottom and top elevators of the bins were to be such that the bins might be filled from cross-conveyor belts running from the bin floor of S; and emptied into conveyors running in tunnels under the storage house to shipping hoppers in the basement of S. As the height from the main floor to the bin floor of the steel house is 117 ft., this required unusually tall storage bins. A height of bin of 110 ft. was fixed upon. The working units of S are placed 40 ft. 6 ins. centers. This determined the center to center distance longitudinally as 20 ft. 3 ins. Transversely the spacing of the bins was increased to 21 ft. 9 ins., thus obtaining a very considerable increase in the capacity of the interspace bins at very small cost. The dimensions of the cupola were fixed by the requirements of the system of distribution to the storage bins. Fixed spouts leading from stationary hoppers were preferred to trippers operating on the conveyor belts, though this arrangement necessitated a somewhat higher cupola than would have been required with trippers.

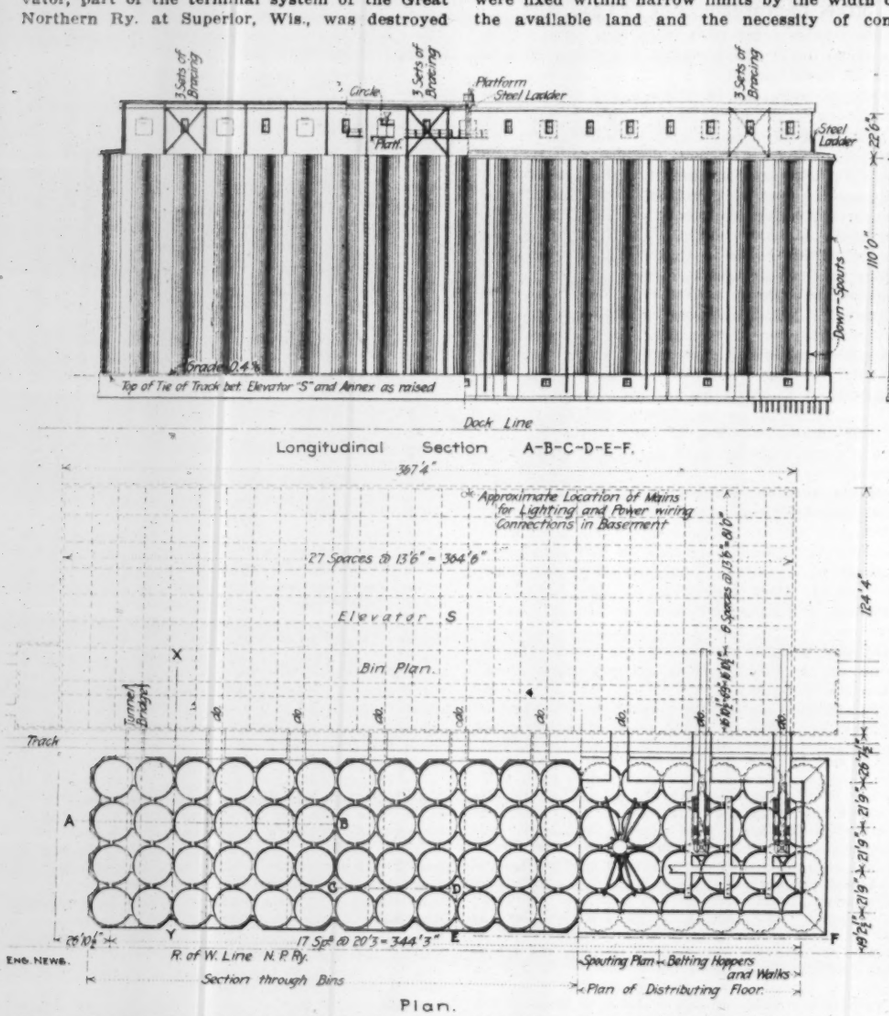


FIG. 1. PLAN AND ELEVATION OF REINFORCED-CONCRETE STORAGE BINS BUILT AS ANNEX TO ELEVATORS OF THE GREAT NORTHERN RY., AT SUPERIOR, WIS.

What follows is a description of the storage bins and the method of construction. Competitive bids were solicited on three types of house: reinforced concrete, steel and tile, the basement to be the same for all types. The lowest bids were received were those for a reinforced-concrete house, and one of these, that of the Barnett & Record Co., of Minneapolis, was accepted.

Design.

The nature of the underlying soil at the site of the storage house is such that a complete pile support was decided upon; no dependure was placed upon the bearing power of the soil between the piles. The height of the grain bins is so great and the resulting load on the foundation so heavy that it was necessary to drive piles over the entire area of the excavation at about as close spacing as practicable for driving. Approximately 5,000 piles were driven. The load per pile is 26 tons. Practically the whole of the load on the piles, amounting to 3½ tons per ft. over the entire area, is delivered to the bottom slab, and thus to the piles, through the outside walls and subdividing walls of the basement. Except at the belt tunnels, these walls were placed so close together that there was no necessity of designing the bottom slab as a beam. The footings of the walls, with a projection of

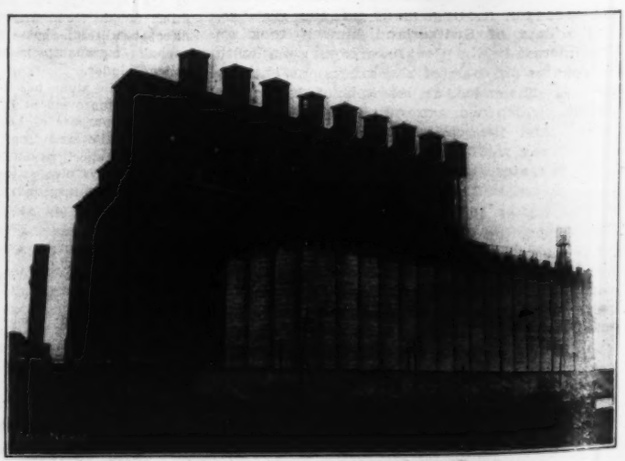


FIG. 2. VIEW OF GRAIN BINS IN COURSE OF CONSTRUCTION.

*1930 Laurel Ave., St. Paul, Minn.

ft. each side of the wall, together with the ft. depth of the slab, were sufficient to care for the distribution of loads to the piles. At the conveyor tunnels, however, it was necessary to have a 7-ft. clear space between walls, and in order to get the proper amount of load to the piles under the middle of the tunnels, the upper part of the slab was reinforced with 1-in. sq. corrugated bars placed 4 ins. c. to c. Three-fourths of these bars were turned down to take shear and diagonal tension. In order to tie the whole of the slab together the fourth bar was made continuous for the full length of the basement, using 27-in. laps at points of no stress (Fig. 4).

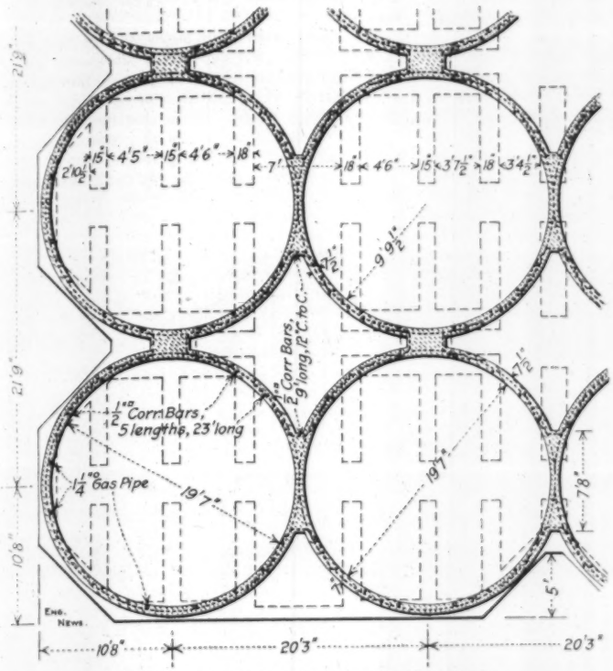


FIG. 3. DETAILS OF BIN CONSTRUCTION.

The second problem in distribution was to get the loads from the bin walls into the basement walls, and from these into the slab. With bins of the height and diameter used, nearly the whole of the grain load is carried by the walls, and this, added to dead loads, gave a total of about 45,000 lbs. per lin. ft. of wall at the bottom of the bins. In order to distribute this load, 20-in. standard I-beams, weighing 80 lbs. per ft., were used over the conveyor tunnels. Reinforced-concrete girders, 3 ft. deep and 8 ft. 9 ins. long, were used for the shorter spans between subdividing walls. In some cases the basement subdivision walls are required to take stresses as beams. In such cases they were considered as very large inverted T-beams, the 2-ft. bottom slab taking the place of the floor-slab in the ordinary T-beam. As it was necessary that the slab and walls should be built at different times, inclined bars were built into both to take care of the longitudinal shear (Fig. 4).

Grain pressure on the bottoms of the bins was taken care of by a reinforced-concrete slab 6 ins. thick, spanning the short spaces between subdividing walls of the basement. This reinforcement was not really needed to care for the grain pressures, though designed for that purpose; for the material used for hoppering the bottoms of the bins was sufficiently hard to arch over the distance between supporting walls. The slab reinforcement was of real value, however, in carrying this hoppering material until it set.

In the construction of the basement slab and walls, 1:2½:5 concrete was used, both sandstone and gravel being used as aggregate. The whole of the upper 3 ft. of the basement is of 1:2:4 concrete. Medium steel corrugated bars were used throughout. The stresses allowed were as follows:

Steel in tension—16,000 lbs. per sq. in.
Concrete in compression—600 lbs. per sq. in.
Concrete in shear—40 lbs. per sq. in.
Adhesion of concrete to bars—100 lbs. per sq. in.

The ratio of moduli of elasticity of steel and concrete was taken as 12.

The design of the bin walls was as shown in Fig. 2. The thickness at the bottom was determined by the compression due to vertical loads, except that the walls were made somewhat thicker than theoretically required. The outer walls, having a grain friction on one side only were made 7 ins. thick, ½-in. thinner than the inside walls. The extra ½-in. of thickness of the inner walls was considered advisable, not only on account of the greater vertical pressure, but because of the fact that these walls act as arches when circular bins are empty and the adjacent interspace bins are full. Theoretically the thickness of the bin walls may be made to diminish from the bottom to the top. Practically, however, the maximum thickness must be maintained for the full height so as to permit the use of sliding forms in the construction.

Bursting pressure in the bins was cared for by using plain round bars, ⅝-in. and ½-in. in diameter, spaced according to the bursting load. The circular bins were tied together and the bursting pressures of the interspace bins provided for by corrugated bars bent into U-shape, placed in the intersections of the bins.

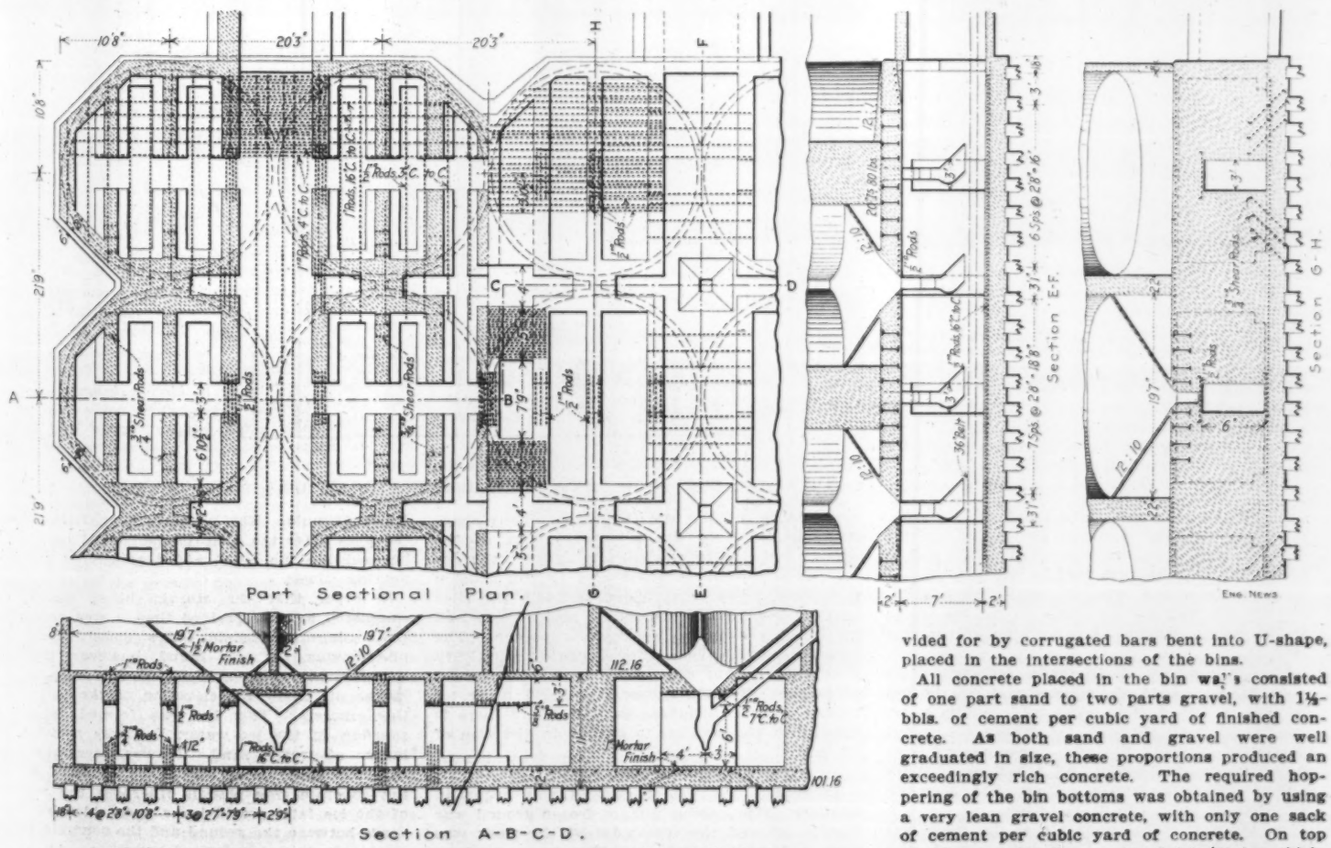


FIG. 4. DETAILS OF BOTTOM OUTLET AND FOUNDATION OF BINS.

All concrete placed in the bin walls consisted of one part sand to two parts gravel, with 1½ bbls. of cement per cubic yard of finished concrete. As both sand and gravel were well graduated in size, these proportions produced an exceedingly rich concrete. The required hoppering of the bin bottoms was obtained by using a very lean gravel concrete, with only one sack of cement per cubic yard of concrete. On top of this was placed a mortar finish 1½ ins. thick.

This lean concrete hardened up in a very satisfactory manner. To make sure that the bins would clear themselves of grain without shoveling, the bottoms were sloped 10 ins. vertically in 12 ins. horizontally.

The cupola consists of a steel framework, resting on the bin walls, enclosed by and supporting 6-in. reinforced-concrete side walls. These walls were reinforced for wind pressure only. The roof consisted of reinforced-concrete tile, resting on steel tees, and covered with four-ply pitch and gravel roofing. The roof tile were made according to the standard construction of the contractor. They are 18-in. span, 24 ins. long and 1½ ins. thick, reinforced with woven wire. Two of these tile were subjected to loads of 1,280 lbs., 640 lbs. at each third point of the span, uniformly distributed along the length of the tile. No sign of failure was noted. This load is equivalent to a uniform load of 569 lbs. per sq. ft. of surface, and was, of course, very satisfactory, not only for the roof, but for the walks in the cupola, where the same kind of tile was used.

All grain spouts were made rectangular in cross-section. Tops and sides are of No. 14 and bottoms of No. 8 sheet steel. To facilitate the renewal of worn sections, the spouts are bolted up instead of being riveted. Bolted spouts have been used by the company for a number of years with satisfactory results. There has been no loosening of bolts due to vibration.

The upper conveyor belts are 42 ins. wide and the lower belts 36 ins. These belts are of solid woven canvas, with a thin rubber coating, and are spliced with copper belt fasteners. The lower belts are driven by new 15-HP. alternating current motors, and the upper belts by eight 15-HP. motors of an old type and one new 20-HP. motor. These old 15-HP. motors had been in use for a number of years, but were considered fully as powerful as 20-HP. motors of present-day types.

The drive pulleys and idlers for the conveyor belts were specified to be cast in one piece. A great deal of difficulty had been experienced by the railway company through the use of drive and idler rolls made up of two or three pulleys on one shaft. With a roll made up in this way it is necessary that the individual pulleys should be placed with their rims touching, as any space between the rims would cause cutting of the rubber belt. With the rims in contact the deflection of the roller shaft due to belt tension puts such heavy compressive stress in the rims that in some cases pieces are broken out, and in others the pulley spokes are broken. The difficulty could have been overcome by using very heavy shafts, but the use of solid rims seemed preferable. The difficulties mentioned occur, of course, only with pulleys located where there is heavy belt tension, due to change in direction of the belt.

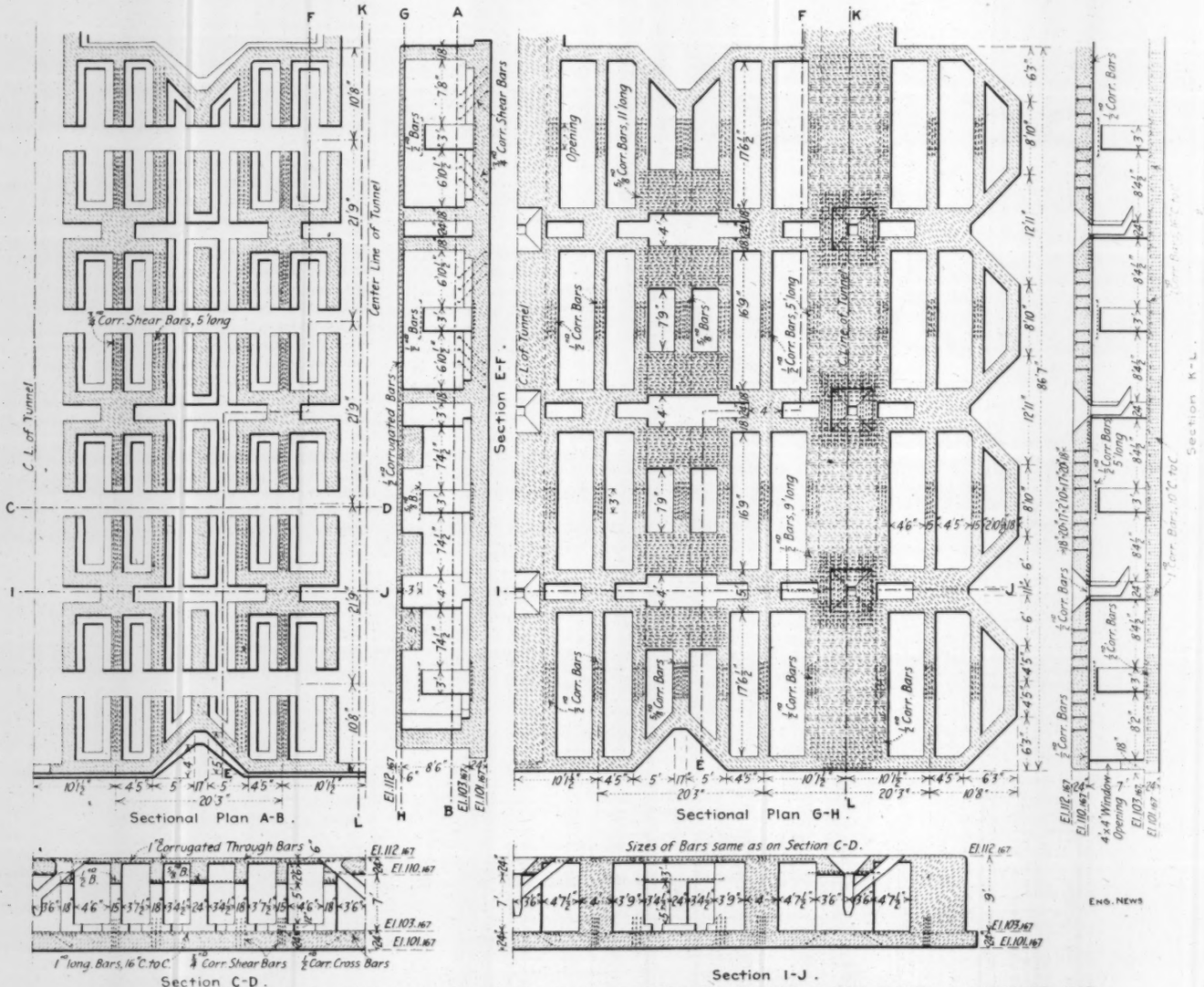


FIG. 5. DETAILS OF BASEMENT AND FOUNDATIONS OF REINFORCED-CONCRETE STORAGE BINS, SUPERIOR, WIS.

Construction.

Excavation for the foundation was begun in January, 1909. About 2 ft. of frozen ground was blasted off and the remainder of the work was done with pick and shovel. Skips were filled by hand and emptied into cars by means of two derricks. A railway track on each side of the excavation made this method possible, and it proved to be a very economical one. To allow for the swelling of the ground due to pile driving the excavation was carried to a depth 3 ft. below the elevation fixed for the bottom of the concrete.

The piling used was Norway pine and timber-rack. In the driving, water-jets were used to penetrate several layers of gravel, but the piles were driven 10 or 12 ft. deeper than the jets were allowed to go. With this method of driving the penetration under the last blows were such that a safe bearing power of about 40 tons was indicated, according to the Engineering News formula. The settling of material about the piles after the disturbance caused by the jet had subsided no doubt added greatly to the safe bearing power.

In order that the storage house should be completed by the specified time it was necessary that concreting should follow closely upon the pile driving. It was found, however, that ice with a depth of from 18 ins. to 3 ft. had formed in the pit below the elevation of the bottom of the concrete. This ice was formed from the overflow of the jet water, and was mixed with layers of frozen sand. It was necessary that this frozen material should be removed before the concrete was placed, otherwise the melting of the ice later would leave a considerable open space between the ground and the concrete which might result in rotting of the piles. An alter-

native course that was suggested was to allow this void to form between the ground and the concrete, and fill it later by pumping in sand with a suction dredge. This would have been a very easy and convenient solution, but it was feared that the open space would not be completely filled. It was finally decided to thaw out the frozen material by the use of steam jets inserted into it. For this purpose a 50-HP. boiler was set up in the excavation and four lines of 1-in. steam hose run from it, terminating in 6-ft. lengths of ¾-in. gas pipe with ⅜-in. reducers and nipples at the end. With 90 lbs. pressure on the boiler, this arrangement was capable of thawing from 20 to 25 cu. yds. of frozen material per day of ten hours, with the temperature at about 10° above zero. This rate was altogether too slow for the purpose, so a 3-in. steam pipe was run from the railway company's power-house at the end of the excavation, and connected to 12 jets such as described above. The pressure in the power-house boilers was kept at about 110 lbs. This arrangement proved very effective. The difference of 20 lbs. in steam pressure increased the efficiency of the jets probably 100%. As the steaming out of the ice progressed, sand and gravel was dumped in around the heads of the piles, and tamped to give a bearing for the concrete.

In the concreting of the basement no problems of particular interest were encountered, except possibly that of finding points in the complicated system of walls, girders and slabs, where the breaks between different day's work could be made without weakening the construction. In the girders and slabs the joints were made about at the quarter points of the spans, and were made approximately parallel to the lines of diagonal tension; that is, at right angles to the cracks that would form if failure by diagonal tension should occur.

Concreting of the bin walls was done in sliding forms of the type commonly used in the west. These forms were of wood, covered with galvanized sheet-iron, and were 4 ft. deep. Outer and inner forms were connected by wooden yokes, so as to move together. The raising of the forms was done by jacks connected to the yokes, and working on 1¼-in. gas pipes fixed in the wall already placed. In order to prevent the concrete from being raised with the forms, the inner forms of the bins were slightly tapered toward the bottom, and the connection between outer and inner forms was made such that the distance between them could be slightly increased after the concrete has set up. All inner forms, 19 ft. 7 ins. in diameter, were planked over, providing a good platform for wheeling concrete and placing rods.

It will be noted in the design that vertical corrugated bars were used in the bin walls. It was the intention to have all horizontal bars wired to each of these vertical bars, as well as to the vertical gas-pipes. It was found, however, almost impossible to do this and get good results on account of the method necessary in placing the horizontals. This method was to draw the bars into place around the verticals, then wire them into hoops. These hoops were then fastened to the verticals with loose loops of wire, and pushed down into place between the forms. It was comparatively easy to push the hoops down if they were wired to the smooth gas-pipes only, but not if they were wired to the corrugated bars. It was found perfectly satisfactory to wire the hoops to the gas-pipes only, and this was done in the greater part of the work. The hoop-bars were specified to be bent into a hook at the ends. This was done in the material yard, but otherwise the bars were sent up to the placing crew straight. The diameter of the bins was such that the straight bars could be drawn into place without difficulty. There was no difference noticable in the labor of placing ⅝ and ½-in. bars, but ¾-in bars would probably be too stiff to handle in this way without a good deal of difficulty. Corrugated bars would be almost impossible to handle, as the corrugations would cause them to bind while being drawn into place. Two lengths of bar were used to form one hoop. In placing the hoops the splices of each were put 45° ahead of those of the preceding hoop, giving at every point of the circumference not less than three unspliced bars to each that was spliced, and insuring a high efficiency in resisting bursting pressures.

Concreting of the bin walls progressed at an average rate of 30 ins. in height per day of ten hours. This average was considerably exceeded in the latter part of the work, when a rate of 36 to 40 ins. per day was usually attained. Each inch of height required about 9 cu. yds. of concrete for the whole group of bins.

As a rule the concrete was put in in two layers per day. A night force got the forms ready for the day's run, putting the tops of the forms about 30 ins. above the top of the concrete placed the day before. About 16 ins. of concrete was placed in the forenoon, finishing up about eleven o'clock. The forms were then raised a few inches, so as to give sufficient depth for the afternoon pouring. This raising was done when the new concrete was from three to four hours old. The balance of the day's run was placed in the afternoon, beginning about half past two. The night force them came on and raised the forms again for next day's work. By this method, concrete placed in the forenoon was left exposed by the raising of the forms about midnight of the same day. Very little difficulty was experienced with this method. Of course, it is necessary that a quick setting cement should be used.

After the completion of the concrete work, all exterior concrete surfaces were treated with a cement and alum wash, both as a partial waterproofing and as a finish. The construction of the storage house was practically complete by Sept. 15, 1909. The bins were filled about Oct. 1, 60 days after concreting.

The above described work was designed and constructed under the direction of Mr. A. H. Hogeland, Chief Engineer, Great Northern Ry. Mr. Max Toltz was consulting engineer on design and construction. The writer was engineer in charge of all construction work except excavation and pile-driving, working under the direction of the Bridge Engineer, Mr. Geo. A. Casseday, and his sucessor, Mr. Jno. A. Bohland. The contractor was the Barnett & Record Co., of Minneapolis, Minn.

A Pumping Engine Taking Steam at Atmospheric Pressure.

An interesting small steam pump designed for about the same service furnished by hot-air engines has recently been marketed in England and, judging from testimonials of a few purchasers there, is proving a success as an automatic lift and force pump. The pump can almost be said to be run by a teakettle, at it takes steam, at or near atmospheric pressure, from a small steam boiler beneath which is a petroleum burner fitted to a small reservoir. The Lamp pump so called, is made in several models, all designed for safe and automatic operation with only occasional attention, such as to renew the fuel supply. The general appearance of one of the Lamp pumps is shown in Fig. 1. This pump is rated to deliver 300 gals. of water per hour to a height 60 ft., above natural level, or 400 gals. 45 ft., with a fuel consumption of about ⅛-gal. per hour. These ratings are about equivalent to 0.1 HP. and 1.25 gals. per HP.-hr., respectively.

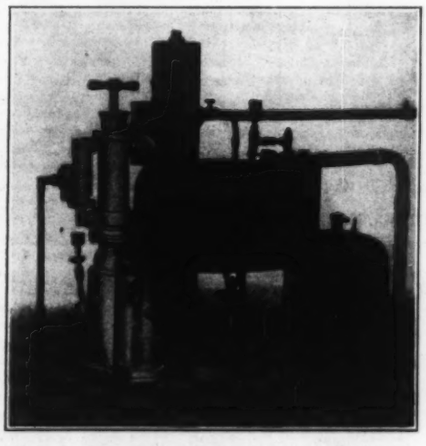


Fig. 1. The Lamp Steam Pump (Babcock's Patent).

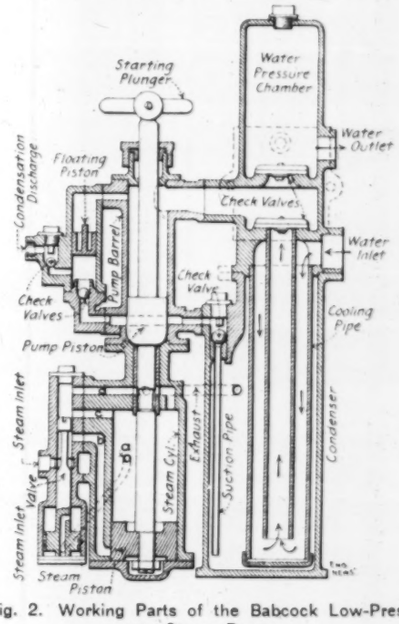


Fig. 2. Working Parts of the Babcock Low-Pressure Steam Pump.

The pump would occupy a floor space about 2½ × 2½ ft., and would be some 3½ ft. high.

The operation of this novel pumping engine may be seen by examining Fig. 2. Water, while being pumped, is caused to circulate through a large cooling pipe in the condensing chamber, furnishing the vacuum that is essential to the operation of the pump. Water is forced on the up stroke only and is allowed, or caused, to enter the pump cylinder on the down stroke. During the up stroke the underside of the pump piston with the pump barrel serves as a vacuum pump to drain the condenser of water, oil or air. If steam has been raised in the boiler, a few hand strokes of the piston (by the starting plunger) will start the pump by filling the cooling pipe with water and partially exhausting the condensing chamber.

In normal operation, the piston is raised by the unbalance of a vacuum above it and a slight pressure of steam under it. Near the end of the stroke the port *a* is uncovered so that steam is admitted to the valve chest (connecting pipe shown dotted). This causes the steam inlet valve to move up as the upper valve piston is connected to the condenser and is under vacuum. The valve stroke is cushioned by steam admitted to the chamber above the main valve piston. By the valve movement steam is cut off, the condenser connection to the piston is broken and both sides of the piston are in communication through the ports *b* and *c*. Now the weight of the whole piston and plunger, assisted by the vacuum on the underside of the pump piston causes the down stroke. When the port *a* has again been uncovered by the piston, near the end of the down stroke, the neck of the piston rod is opposite the ports in the gland and the condenser is connected to the space above the working piston and to that below the main valve piston. The valve then falls, through the expansion of the cushioned steam in the buffer chamber and the action of the vacuum underneath its piston. The cycle is then complete.

There are modifications of the design described, having a fly-wheel and driving a deep-well pump. The arrangements shown are patented in this country as well as in Great Britain though not manufactured here. The English manufacturer is the Lamp Pump Syndicate, 12 Carey St., Westminster, London, S. W., to whom we are indebted for this description.

American Electric Locomotives.

A convenient summary of the type, equipment and service characteristics of electric locomotives used in trunk-line railway service is given by Tables I. and II. herewith. These tables are reproduced from an appendix to the paper of Mr. George Westinghouse before the British meeting of the American Society of Mechanical Engineers, abstracted in our issue of July 7, 1910. They also form a useful supplement to the discussion of locomotive design by Storer and Eaton, in this issue.

The following notes on the several locomotives amplify the tabulated information:

Locomotives Built by the Westinghouse Electric & Mfg. Co. (See Table I.)

NEW HAVEN.—The first column covers locomotives built for the New York, New Haven & Hartford R. R., for operation on their electrified zone between New York and New Haven. The electrical system demanded that the locomotives be capable of operation both on single-phase and direct current. There are 41 of these locomotives in operation. A gearless concentric motor for each driving axle is mounted on a quill flexibly connected to the driving wheels. The dead weight on the axles is thus reduced to a minimum.

GRAND TRUNK.—The second column covers locomotives built for the Grand Trunk Ry. for operation in the St. Clair Tunnel under the St. Clair River. These locomotives are designed for operation with single-phase current only. They are handling the entire freight and passenger traffic through the tunnel.

PENNSYLVANIA.—The third column covers locomotives built for the Pennsylvania R. R. for operation in their New York tunnel. They are for passenger service only and operate on direct current at 600 volts on the conductor. The first locomotive has been run 17,000 miles on test. The center of gravity of these locomotives is high, as the motor is mounted well above the driving axles. The transmission from motor to wheels is by cranks and connecting rods. These parts are protected from possible damage due to short circuit by interposing between the armature and its shaft a friction clutch which will slip before damaging stresses are imposed on the transmission. The motors are the largest railway motors ever built and are provided with commutating poles, making possible the use of a shunted field control which is applied to these locomotives.

NEW HAVEN.—The fourth column covers a locomotive built for the New York, New Haven & Hartford R. R. for use in high-speed freight and medium-speed passenger service. It also is fitted for operation both with single-phase and direct current. It has been run approximately 3,000 miles in test service, actually hauling regular freight trains, including the steam locomotives, over the electrified section of the railroad on the normal schedules for the movement of these trains. A pinion at each end of the motor meshes with a flexible gear whose center is rigidly secured to the quill surrounding the axle, the flexible gear overcoming the difficulties in securing tooth alinement and division of load which are liable to occur when rigid twin gears are used. It is the only electric locomotive equipped with spur-geared motors which are bolted rigidly to the spring-supported parts of the locomotive. Each driving wheel is driven through helical springs, the arrangement being such that the driving wheel has practically free vertical play. The locomotive has two trucks, the draw-bar pull being transmitted through the truck frames. The body is spring-mounted on friction plates in place of being carried on truck center pins in the usual manner. It is an exceptionally easy riding machine with very low rolling friction. The performance has been satisfactory, and a speed of 40 miles per hour was attained on level track with a 1,600-ton train.

NEW HAVEN.—The fifth column covers a locomotive for the same railroad and service as that just described. The comparison between geared and connecting-rod motors for identical service is a very interesting feature of this development. The weights given in both the fourth and fifth columns are those on which locomotives of these types would generally be built. The actual locomotives are somewhat heavier, due to particular features of design not inherent in the type. The effect on the connecting rods and pins of the pulsating torque of a single-phase current is avoided by the introduction of a flexible connection between the armature and its shaft. This locomotive has not been tested.

These last two locomotives were ordered by the New Haven road to demonstrate the practicability of electric traction for freight service and to assist in determining the most suitable kind or type of locomotive.

Locomotives Built by the General Electric Co. (See Table II.)

NEW YORK CENTRAL.—The first column covers locomotives built for the New York Central & Hudson River R. R. for operation on the electrified zone of the New York City terminal. Forty-seven of these locomotives are in use, the first having been put in operation in July, 1906. They are used for passenger service only, and operate on direct current at 600 volts. The mechanical equipment of this locomotive consists of a main driving-wheel-base with four driving axles and a four-wheel guiding truck at either end. The motor is of the bipolar gearless type, the armature being mounted directly on the driving axle, and the mechanical structure of the locomotive forming a portion of the magnetic circuit of the motors. The characteristic feature of the locomotive is the simplicity of its electrical and mechanical construction, which contributes to its high efficiency and low maintenance cost.

MICHIGAN CENTRAL.—The second column of Table II. covers locomotives built for operation at the Detroit River Tunnel. These are to be used for both freight and passenger service between Detroit, Mich., and Windsor, Ont., and will be operated at 600 volts, direct current. The running gear consists of two trucks connected together with a massive hinge so as to form a single articulated wheel base, and buffers carried on the outer end frames of the trucks. The motor is of the direct-current geared type with commutating poles and is interesting as the first application of the commutating pole motor to this class of service. Twin gearing is used beween the motor and driving axle, and consists of a pinion at each end of the armature shaft and a corresponding gear on the axle. The use of twin gearing relieves the armature shaft of torsional strains and maintains the parallelism of the shaft and axle. Five of these locomotives have been built and are awaiting completion of the tunnel. While they are not in actual operation, extensive tests made on a test track in hauling and accelerating freight trains up to 1,500 tons in weight have proved that this type is very satisfactory for the service.

BALTIMORE TUNNEL.—The third column covers locomotives built for the Baltimore & Ohio R. R. for operation of both freight and passenger service through the Baltimore Belt Line Tunnel. Two of these locomotives are in use and operate on direct current at 600 volts. The general design is similar to the Detroit Tunnel locomotive described above and the same type of motors are used, but the motors are geared for higher speed in order to meet the speeds required by passenger service on the relatively lighter grades of the Baltimore Tunnel.

CASCADE TUNNEL.—The fourth column covers locomotives built for the operation of freight and passenger trains through the Cascade Tunnel of the Great Northern Ry. These locomotives are designed for three-phase operation at 25 cycles and 6,600 volts on the trolley. The mechanical structure consists of an articulated wheel-base similar to that of the Detroit River Tunnel locomotive described above. The motor is a three-phase induction motor with external secondary resistance and fitted with a gear at each end of the armature shaft. The service for which they are ultimately designed is the operation of a division 57 miles long with ruling grades of 2.2% and an average grade of 1.55%. Four of these locomotives are in service and it may be of interest to note that they were involved in the disastrous avalanche of March 1, 1910, which swept through the electrified yards at Wellington, Wash.

PARIS-ORLEANS.—The fifth column covers locomotives built for the Paris-Orleans Ry., for use in hauling passenger trains from the Austerlitz Station to the Quai d'Orsay. They are designed for operating on 600 volts, direct current. These locomotives are historically of interest, the first one of them having been delivered in 1899, and twelve being now in service. Each locomotive has two independent trucks, each truck equipped with two geared motors, and carrying weight of cab and platform on the center pin with draft gear and buffer attached to this platform. This represents a type of locomotive of which a large number have been built, and which has proved highly satisfactory for light and medium classes of service.

TABLE I.—DATA OF WESTINGHOUSE E. & MFG. CO.'S ELECTRIC LOCOMOTIVES.

Built for	New Haven	Grand Trunk St. Clair Tunnel	Pennsylvania	New Haven	New Haven
Electric system	A.C., D.C.	A.C.	D.C.	A.C., D.C.	A.C., D.C.
Service	Passenger	Frt. & Pass.	Passenger	Frt. & Pass.	Frt. & Pass. building
First placed in service	July 1907	February 1908	17,000-mile test	3000-mile test	
No. in service or on order May 1910	41	6	24	1	1
No. motors per locomotive	4	3	2	4	2
Armature diameter, inches	39½	30	56	39½	76
Core length, including vent opening, inches	18	14¾	23	13	13
Weight one motor, pounds	16,420	15,860	45,000	19,770	41,600
Weight all motors on locomotive	65,680	46,980	90,000	79,080	83,200
Weight all electrical parts	110,400	88,400	127,200	130,000	135,000
Weight all mechanical parts	94,100	73,600	204,800	130,000	125,000
Weight complete locomotive	204,500	132,000	332,000	260,000	260,000
Weight on driving wheels	162,000	122,000	207,800	180,000	180,000
Weight complete locomotive for A.C. operation	196,000	132,000	D.C.	241,000	240,000
Max. guar'd'd speed, miles per hr.	about 58	30	about 80	46	45
Feature limiting speed	track	armatures	connecting rod	armatures	armatures
Max. tractive effort	19,200	43,800	69,300	40,000	40,000
Loco. wt. in excess of 18% adhesion Max. T.E., A.C. operation	88,700	none	none	18,500	17,500
Designed for trailing load, tons	250	800	550	(1800 freight, 800 pass.	(1800 freight, 800 pass.
Balance speed on level with above load	about 75	about 25	60	(35 freight, 45 pass.	(35 freight, 45 pass.

TABLE II.—DATA OF GENERAL ELECTRIC CO.'S ELECTRIC LOCOMOTIVES.

Built for	N. Y. C. & H. R. R.	Detroit River Tunnel	B. & O. R. R.	Great Northern	Paris-Orleans
Electric system	D.C.	D.C.	D.C.	3-phase	D.C.
Service	Passenger	Frt. & Pass.	Frt. & Pass.	Frt. & Pass.	Passenger
First placed in service	July 1906	tests completed	March 1910	July 1909	1899
No. in service or on order May 1910	47	6	2	4	11
No. motors per locomotive	4	4	4	4	4
Armature diameter, inches	29	25	25	38¾	23½
Core length, including vent opening, inches	19	11½	11½	16¾	12
Weight one motor, pounds	18,150	10,560	10,560	15,000	8,855
Weight all motors on locomotive	72,600	42,240	42,240	60,000	35,420
Weight all electrical parts	91,200	54,000	54,000	100,000	42,500
Weight all mechanical parts	138,800	146,000	130,000	121,000	67,500
Weight complete locomotive	230,000	200,000	184,000	230,000	110,000
Weight on driving wheels	141,000	200,000	184,000	230,000	110,000
Weight complete locomotive for A.C. operation	D.C.	D.C.	D.C.	230,000	D.C.
Max. guar'd'd speed, miles per hr.	75	30	35	30	45
Feature limiting speed	track	armature	armature	armature	armature
Max. tractive effort	47,000	67,000	61,000	77,000	37,000
Loco. wt. in excess of 18% adhesion Max. T.E., A.C. operation	none	none	none	none	none
Designed for trailing load, tons—Freight		900 on 600 2% grade	850 on 500 1½% grade	500 on 2.2% grade	
Passenger					
Balance speed on level with above load	435 / 63	Freight 30.5 / Pass. 22	Freight 26 / Pass. 30	15	300 / 33

THE LONGEVITY OF THE IRON ORE SUPPLY is discussed in an interesting manner by Prof. Henry M. Howe, School of Mines, Columbia University, New York City, in the "Atlantic Monthly" for June, 1910. The tone of the discussion is indicated in part by the title given to the article, which is "An Optimist's View of the Iron-Ore Supply." We quote Prof. Howe's conclusions as follows:

> Let me sum up my argument. When we come to consider the effect which the drafts on our iron-ore resources will have in increasing the cost of iron as measured in days of labor, we see that this effect will not be felt oppressively until after an incalculable age, if indeed it ever is: first and chiefly because of the inconceivable immensity of the stores of potential poor and deep-seated ores; second, because the cost of the iron in the ore is only a fraction, often only an insignificant fraction, of the cost of the iron articles of our actual use, so that a considerable percentage of increase in the cost of the former causes only an inconsiderable increase in the cost of the latter; and third, because our sense of this increase will be dulled by the simultaneous rise in the cost of almost all other tangible things. To the hardship of this general rise, even to the total disappearance of that most precious deodand, our coal, we shall certainly learn to accommodate ourselves. And though the fraction of this hardship which consists of the increase in the cost of iron may be greater than some of the other fractions of discomfort, such as those formed by the advance in the cost of the other metals, and of certain animal and vegetable products, yet it will not differ from the accompanying fractions taken severally, and certainly not from their sum, in such a way as to be felt oppressively and apart from the rest.
>
> Let us husband our iron ore, like every other gift of God. But when we cry out to others to join in the husbandry, let our appeal square with the facts, that those who hear may heed.

The Design of the Electric Locomotive.*

By N. W. STORER and G. M. EATON.†

Features of an Electric Locomotive.

Many features to be embodied in an ideal electric locomotive depend entirely on the point of view. Any electric locomotive, however, must contain certain essential features.

(1) Mechanical parts of strength sufficient for the required service; (2) Motors of capacity sufficient to develop the required power; (3) A reliable transmission between the motors and driving wheels; (4) Weight on driving wheels sufficient for adhesion; (5) A complete control system; (6) Riding qualities enabling the locomotive to negotiate the rails without undue damage.

More or less closely associated with these essentials there is an endless variety of detail concerning which no two men will hold identical opinions. The electric locomotive designer must act as a clearing house for the

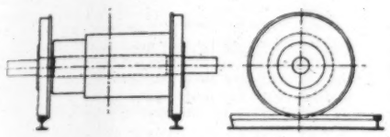


Fig. 1. New York Central. Gearless Motor.

opinions and ideals of all the men associated with railroad electrification. To prepare himself for this position, he must view the locomotive through the eyes of men connected with every branch of the service.

LOCOMOTIVE IDEALS.—The man who is responsible for hauling trains on schedule time sees a perspective that does not include first cost, weight, or mechanical or electrical efficiency, as those terms are generally understood. He sees in the electric locomotive only a means for keeping his trains moving, and on schedule time. His conception of efficiency is represented by the number of trips made on schedule time, divided by the total number of trips. He accepts an electric locomotive only as a last resort, and then recommends the incorporation of as many as possible of the features of his successful steam locomotives. This on the face of it is a wise plan, but it should be remembered that a locomotive may be successful because of a given detail or it may be successful notwithstanding that particular feature. Again, a certain feature may be successful because of interrelation with other features, and a new design of locomotive must be carefully analyzed to see that an old and proven device will have the environment necessary for its best success. Too much emphasis cannot be laid on this point, as the differences in principle between steam and electric locomotives are not always easily recognizable. This point is well illustrated by fundamental differences in the application of cranks and connecting rods on steam and electric locomotives, which will be discussed in detail later.

The eyes of the motive-power man see much the same features as those of the operating man, but his eyes magnify details of design in a greater degree. Both will wish to incorporate as many standard parts as can be used, and they will insist on the strength of all parts being ample to withstand every phase of the service such as bumping, speeding, overhauling, etc. They will be interested in the machine involving low maintenance charges, but in this respect they will not fully fore-

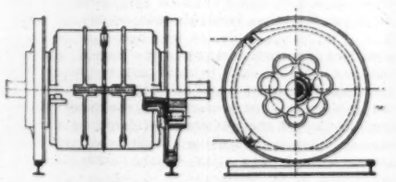


Fig. 2. New Haven. Gearless Motor With Flexible Connections.

see the effect of the various mechanical features upon the electrical equipment, and they are liable to insist on the adoption of mechanical details, which of themselves have a low cost of maintenance, and yet at the same time will involve an excessive cost for the maintenance of the electrical equipment. Their ideal locomotive will operate safely at high speed, in either direction. It will be able to make up a reasonable amount of lost time, and will always be ready for service. It will not require long lay-overs, and will be in the shop the least possible time. They would like if possible a single type of locomotive which would perform any service that might be required of it, from making up and hauling a 2,500-ton freight train to making a high-speed run with a "limited."

The amount of power consumed and the excessive weight involved in an interchangeable locomotive of this type are a matter of little importance to them, so long as the locomotive is strong enough to stand every phase of the service, and does not call forth protests from the maintenance-of-way department and bridge engineers. They know that such protests will certainly be forthcoming if damage to track and bridges is greater than that attendant upon the operation of the accepted types of steam locomotives.

Up to within a short time it has been the accepted idea that an electric locomotive would have riding qualities greatly superior to those of the steam locomotive, and that it would cause much less track destruction, due to the perfect balance and the absence of reciprocating parts. Recent experience has demonstrated that these features in themselves are not sufficient to produce a good tracking locomotive, and it is now generally recognized that the proportioning of an electric locomotive which will have ideal riding qualities is one of the most serious problems to-day confronting the designer.

The ideal locomotive of the general manager or president of the railroad is one that will meet as nearly as possible the ideals of his subordinates, and in addition will be a part of that system which will give the most reliable service, consistent with a reasonable cost of operation; or, in other words, will earn the largest dividends on the investment. The cost of the locomotive will appeal most strongly to him.

It is popularly supposed that the ideals of the electrical engineer concerning electric locomotives embrace only the electrical details of the locomotive, such as motor design, efficiency, temperature, and the control and collecting system, but this is a mistake at the present time, whatever it may have been in the past. It is necessary for him to have the broadest possible ideal. It is his duty in connection with steam locomotive designers to select that combination of details which will be the best compromise of the ideals of all railway people. It must be recognized that every complete design is a compromise, as much so in locomotives as in other machinery, and as long as the ideals of the different departments are conflicting it is certain that an ideal locomotive, from all points of view, will never be secured.

Locomotive Problems.

TRANSMISSIONS.—At first sight it appears to be a very simple problem to transmit the power from rotating armatures to rotating wheels. This, however, is not the case, there being more or less serious objections and limitations to every type of transmission that has been proposed. Many of the types give excellent service when used in their proper places, but the fact remains that for high speeds and also for maximum powers, the problem of transmission is one of the most serious among the mechanical problems confronting the designer.

It will be helpful to classify the various types of transmission. Some of the objections and limitations of these types will be discussed later:

(a) Gearless motor with armature pressed onto driving axle. "New York Central." See Fig. 1. (b) Gearless motor with armature carried on a quill surrounding axle, and driving the wheels through flexible connections. "New Haven Passenger." See Fig. 2. (c) Geared motor with bearings directly on axle and with nose supported on springborne parts of locomotive. "St. Clair Tunnel." See Fig. 3. (d) Geared motor with bearings on a quill surrounding axle, and (1) nose supported on springborne parts of machine (New Haven Car, Fig. 4) and (2) motor, rigidly bolted to springborne parts of machine, the quill having sufficient clearance for axle movements. "Four-motor New Haven Freight." See Fig. 5. (e) Motor mounted rigidly on springborne parts, armature rotating at same rate as drivers, power transmitted to drivers through cranks, connecting rods and countershaft on level with driver axles. "Pennsylvania." See Fig. 6. (f) Motor mounting and transmission as in (e) but motor fitted with double bearings, one part for centering motor crank axle and the other for centering the armature quill which surrounds and is flexible connected to the motor crank axle. "Two-motor New Haven Freight." See Fig. 7. (g) Motors mounted on springborne parts, armature rotating at same rate as drivers, power transmitted to drivers through offset connecting rods and side rods. "Latest Simplon locomotives." See Fig. 8. (h) Motors mounted on springborne parts, armature rotating at same rate as drivers, power transmitted to drivers through Scotch yokes and side rods. "Valtellina Locomotives." See Fig. 10. (i) Motors mounted rigidly on springborne parts, power transmitted through gears to countershaft, thence to drivers through Scotch yokes and side rods. See Fig. 9.

FRAMING.—Further classification of electric locomotives on the basis of framing and wheel arrangement is also of assistance in gaining a clear understanding of existing locomotives.

(a) Cab and framing an integral structure. All weight carried on drivers. Drivers contained in a single rigid wheel base. "St. Clair Tunnel." See Fig. 11. (b) Cab and truck framing separate structures, all weight carried on drivers. Drivers contained in two rigid wheel base trucks. Draw-bar pull transmitted through center pins or through truck frames. "Spokane & Inland Empire Ry. Co." Early P. R. R. types. See Fig. 14. (c) Same as (b) but with added idle wheels for guiding and weight carrying. "Modified New Haven Passenger, and New Haven Freight." See Fig. 13. (d) Any of the foregoing forms permanently coupled in pairs or articulated. "Pennsylvania." See Fig. 16. (e) Same as (a) but with added idle wheels for guiding and weight carrying. "Valtellina or New York Central." See Fig. 13. (f) Cab and framing an integral structure. All weight carried on drivers. Driver wheel base partly rigid and partly flexible. "Simplon Tunnel." See Fig. 12.

SERVICE REQUIREMENTS.—It has been stated that from an operating standpoint it would be very desirable to have one locomotive which would be capable of handling, at the desired speed, any train from the heaviest freight to the fastest limited. While such a locomotive

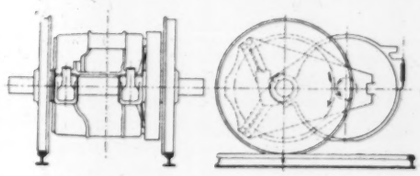


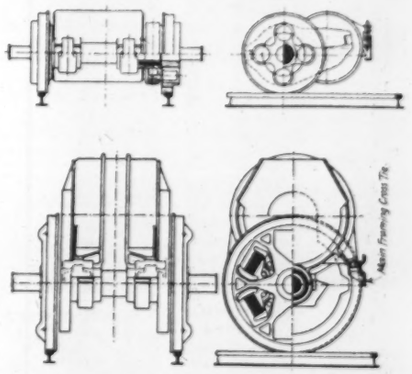
Fig. 3. St. Clair Tunnel. Geared Motor.

can be built, it will be at a prohibitive cost. It is commercially practicable to cover a considerable range of speed and weight of trailing load with one locomotive, and any passenger locomotive may be used to handle on its lower speeds freight trains within its capacity for tractive effort; but where the weights of trains to be handled and the speeds at which they operate vary as widely as they do on most trunk lines, an absolutely interchangeable locomotive is impracticable. This we believe will be shown in the discussion of the requirements for the various classes of service in the following:

Switching Service.—From the nature of this service the locomotive operates to a great extent over the curves and special work. This track construction is expensive and hard to maintain. The locomotive should therefore embody primarily in its design such features as will enable it to negotiate this kind of track with the least effort. We list the chief of such features in approximately the order of their importance.

(a) Short rigid wheel base. (b) Minimum dead weight per axle. (c) Minimum total weight per axle needed for adhesion. (d) Concentration of weight near midlength of locomotive, and short cab overhang. (e) Effective equalization preferably of the three point type. (f) Flexibility of framing under longitudinal twist to assist equalizing system. (g) High center of gravity. While this is of helpful tendency it is probably not worth the expenditure of much money or weight on account of the slow speed of operation.

These features may all be summed up as those tending to produce a locomotive whose wheels may be deflected



Figs. 4 and 5. New Haven. Geared Motors.

by the rails with the least attendant movement of the mass of the locomotive.

A four-wheel steam switcher of a standard type is notable for extreme overhang and consequent nosing characteristic. This overhang is practically inherent in a steam locomotive of minimum wheel base.

Slow Freight Service.—Most of the transcontinental railroads are to-day limited in their carrying capacity by long mountain-grade divisions. The present practice is to run the heaviest freight trains that can be operated over these divisions. This service is now handled by consolidation or Mallet steam engines, which haul 2,000 to 2,500 ton trains at 8 to 10 mi. per hr., and electric locomotives are expected to handle the same or heavier

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†Westinghouse Electric & Manufacturing Co., Pittsburg, Pa.

trains at higher speeds to increase the capacity on the line.

The latest developments in locomotive design indicate that the type of locomotive best suited for such service, with speeds of 12 to 15 mi. per hr. is one having a motor geared to each axle. The feature of prime importance in the design of these locomotives is the absence of weight in excess of that necessary for adhesion. Every ton of excess weight in the locomotive means a ton less trail-

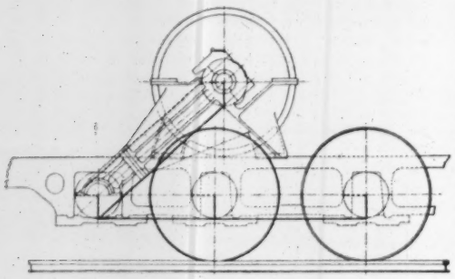

Fig. 6. Pennsylvania. Side Rods.

ing load. A slow-speed freight locomotive should be designed with all weight on the drivers.

In the slow-speed service, the maximum allowable weight per axle should be used if the total weight of locomotive can be thereby reduced. A greater dead weight per axle can probably be tolerated than is wise in switching service, because being a road engine, a much less amount of special work will be negotiated than in the case of a switch engine, and the damage to the track will not be excessive at the normal operating speeds.

If, however, complete spring support of the motors can be achieved without excess total weight, and this can usually be done, then the decrease in maintenance charges should much more than offset the increased first cost attendant upon such spring support.

There is a great difference of opinion among railway engineers both in regard to the total weight per axle and the amount of dead weight allowable. Some would keep the total weight per axle below 40,000 lbs. and the amount of dead weight equal to that of wheels, axles and journal boxes. Others do not hesitate to put 60,000 lbs. on a single pair of wheels with a dead load of 15,000 to 18,000 lbs.

The intention here is not to attempt placing strict limits on axle loads, but to call attention to general tendencies, as each actual installation must be settled upon its own merits, or in accordance with the practice on the particular line involved.

The wheel base of the slow-freight engine should be as flexible as possible so as to curve easily and prevent flange wear, and should take switches and turnouts without undue stress on the track. No idle leading or trailing truck axles will be necessary. The remarks on high center of gravity, equalization, concentration of weight at midlength of engine and flexible framing apply almost equally on switching and slow freight services.

Fast Freight Service.—Some trunk lines have no heavy grades, and are able to operate their freight trains at speeds of 30 to 40 miles per hour, or even higher. For such roads a locomotive adapted to cover a range of speed from 30 to 60 miles per hour is well suited to handle both freight and all but the highest speed passenger trains.

Two points of departure from switching requirements are worthy of particular attention when the speed runs as high as 50 to 60 mi. per hr. One is a requirement of service operation, and another is imposed by the design. These points are interesting in that service requirement and design limitation go hand in hand. First, the speed makes it advisable to provide leading wheels of small size and light dead weight to assist in guiding and more particularly to iron the rails down gently to an actual bearing surface on the roadbed and thus avoid the knock attendant on hammering the free rail down with the heavy drive wheel. Secondly, as the speed increases, either the tractive effort decreases with less weight required on drivers or the horsepower demanded increases with attendant weight increase and the added wheels are necessary to avoid overloading the drive wheels.

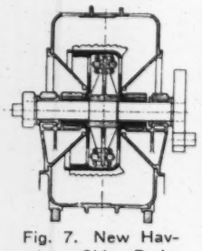

Fig. 7. New Haven. Side Rods, Double Bearings.

High-Speed Passenger Service.—The most important requisite of a locomotive designed to operate at 60 miles per hour and over is its ability to run at the highest speeds possible without injury to the track. All the track disturbances mentioned above, except in curves and special work, have been primarily in a vertical plane. When we consider speeds of 50 to 60 miles per hour, however, we are closely approaching the range where even on tangent track serious lateral disturbance is liable to occur. Extensive speed tests have shown that almost any kind of a machine will stay on the track at 40 mi. per hr., without serious damage to tangent track. As the speeds increase above this figure, however, the bad riding qualities rapidly appear. The particular features following apply with more and more importance as the speed increases so that we are led naturally to a consideration of the higher-speed machines, bearing in mind again that no sharp dividing line exists and individual conditions must govern all concrete cases.

There are certain features that tend to reduce the intensity of the lateral forces on the track. First of these, and a source of much recent comment, is "high center of gravity." The acceptance of this as a cardinal principle of successful high speeding, however, is not universal. The theory on which the belief in the value of a high center of gravity is based is that the higher the mass of the locomotive is placed above the axles, the less will be its restraining influence against lateral motion on the part of the wheels. The mass of the locomotive may take the general direction of the track while the wheels follow all the jittle irregularities in its surface and alinement.

Assume, for instance, that a locomotive is running at high speed on tangent track and that some rail defect imposes sudden transverse movement upon the wheels. Under these conditions the mass of the wheels and axle and any other masses rigidly associated with them will deliver a shock approximating a hammer blow to the side of the rail head. Evidently therefore these masses should be minimized unless it can be shown that their increase does not involve serious injury to the track and consequent danger in operation.

The blow delivered by the springborne parts of the locomotive is radically different from this in both low and high center of gravity machines. In the case of a locomotive whose center of gravity of springborne parts is at the same height as the center of the transverse restraint, i. e., about the center of the axle, the transverse movement of the leading driver would impose a rotation of springborne parts about a vertical axis. The lateral force to impose such a movement would be very great, due to the great moment of inertia about this axis. In the case of a locomotive whose center of gravity is high above the center of transverse restraint the movement imposed upon the springborne masses by transverse movement of the leading driver is a composite of two rotations, viz., about a vertical axis and about a horizontal axis parallel to the rails. As the moment of inertia about the latter axis is much less than that about the former it is evident that the lateral forces involved in the high center of gravity machine will be less. The forces opposing rotation about horizontal axis are provided by the semi-elliptic riding springs, which will transmit their resultants ultimately to the running face of the rail and will not aggravate flange pressures. Were it not for the dampening effect of the friction of the semi-elliptic springs and the detail friction of the machine, this rotation about a horizontal axis would be a simple harmonic vibration. The period and amplitude of this vibration would be functions of the characteristics of the semi-elliptic springs and of the polar moment of inertia of the masses moved.

Suppose for example that with the low center of gravity locomotive first considered, some combination of lateral springs were applied which would impose on the springborne weights a vibration about the vertical axis of period and amplitude and dampening action identical with that occurring on the high center of gravity machine. There being no rotation about the horizontal axis, the forces required to control the vibration would be greater than with the high center of gravity machine, because of greater moment of inertia about the vertical axis; and further, the transverse rail stresses would be greater because the reactions of the controlling forces are transverse.

We can formulate an idea of the springs necessary for such transverse restraint by comparing them with the semi-elliptic riding springs which perform the dual function of supporting weight and resisting rotation about the horizontal axis. Probably transverse springs as heavy and with as great amplitude of motion as these semi-elliptic riding springs would be none too powerful to perform the required service, and it should be noted that their friction is almost as important as their spring action.

The foregoing discussion is predicated upon the assumption that the springborne masses are an integral unit; and it shows, from perhaps a new point of view, that the production of an ideal high-speed, low center of gravity engine of the type noted, while perhaps theoretically possible, is attended by serious if not insurmountable difficulties.

Considering further this horizontal rotation of the springborne masses of a locomotive with medium height of center gravity, we find that there is a zone that is neutral as regards transverse motion relative to the track. If in such a locomotive certain of the lower masses were hung from longitudinal trunnions located on the center line of the locomotive and in this neutral zone, it is evident that the rotation of the springborne masses would be more easily accomplished due to the lessening of the masses moved. Possibly gearless concentric motors could be hung in this way, in connection with a drive of sufficient flexibility to allow free wheel play.

This is not a combination that could be recommended solely because of good riding qualities. It is, however, entirely possible for such a machine to have sufficient attendant simplicity to make it a better compromise than an engine where simplicity and mechanical efficiency are directly sacrificed to secure high center of gravity.

It may be mentioned that the New Haven locomotives have a motor mounting that approximates this condition. There is not as great amplitude of springs to allow unrestrained wheel play either vertically or laterally as might be desired, but there is enough to cushion all blows that the track receives from the mass of the motors, and the reports of track maintenance since the addition of the leading wheels eliminated the nosing tendency, are very gratifying.

Almost equally advantageous with the high center of gravity is the concentration of the mass of the locomotive about this center of gravity, both vertically and longitudinally. It is conceivable that if the mass of the locomotive could be so concentrated longitudinally about the center of gravity as to decrease the radius of gyration about the vertical axis to a value well within the rigid wheel base, there would be no more serious lateral disturbance on the track with a low center of gravity ma-

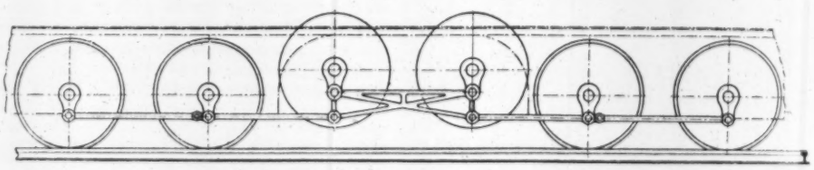

FIG. 8. SIMPLON TUNNEL. SIDE RODS.

chine than with one having higher center of gravity but with a much longer radius of gyration about the vertical axis. Every effort should, therefore, be made to locate the mass of the heavy parts of the locomotive as near the middle as possible.

The action of a low center of gravity locomotive can be very materially improved by locating the point of side restraint below the level of the driving axles. Every inch that this point is lowered is equivalent to raising the center of gravity of the springborne parts by an equal amount.

WHEEL SIZES.—On a steam locomotive, large wheels are considered essential for high-speed service. The primary reasons are to minimize the wear and tear on parts subjected to reciprocating stresses, to maintain the piston speed at a safe figure, and to keep down the blow on the track due to the incorrect counterbalance. An advantage of large wheels in any high-speed engine lies in the attendant low surface speed of the journal, and again in the long time elapsing between tire turnings. There is also less distress of metal in both tire and rail, due to the greater area of contact with the large wheel. On the question of the advantage of large wheels for road engines, there is probably a greater unanimity of opinion among railway men than on any other detail of the equipment.

EQUALIZATION.—The most successful high-speed steam locomotives of to-day are designed with a three-point equalization, having one point ahead and two trailing. This is apparently a very desirable arrangement for any locomotive, and the electric locomotive designer is at once confronted with a new problem in adapting it to a locomotive which must be designed to operate equally well in either direction. The only means by which the actual three-point equalization can be secured on such an engine is to devise some means for shifting the equalization when the engine is reversed. It is possible to arrange air cylinders interlocked to the reverse lever, which will automatically alter the equalization system, so that a single point of equalization will always lead and two-points will always trail. This should, however, be reserved for a last resort, as it does not seem wise to accept such weight and complication unless it proves essential.

A symmetrical arrangement of wheels on the two ends of the locomotive has been criticized by some as leading

itself to a nosing tendency in high-speed engines. While there is some evidence to support such contention, it is not regarded as absolutely proven, and there is an open question as to whether the symmetry of equalization rather than symmetry of wheel arrangement is not the irritating cause.

Whatever system of equalization is used, it is very desirable that the springs on an electric locomotive should be very flexible. This in itself will tend to equalize the loads on the drivers without the complete three-point equalization system. It is contended by some

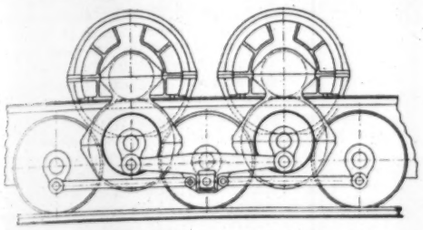

Fig. 9. Combination. Gears, Side Rods and Yoke.

of the best engineers that a four-point equalization system with flexible springs is better than the three-point equalization system.

INTERCHANGEABLE LOCOMOTIVES.—If the accuracy of the foregoing outline of features for various services is accepted, the impracticability of performing all classes of service economically with a single machine, is at once made apparent. The engine for the heavy high-speed passenger train will require motors of large capacity. This capacity, however, can be utilized only at the high speeds with a corresponding low tractive effort. The electric locomotive is not so well suited for interchangeable service as the steam locomotive because of the fact that its continuous tractive effort is practically constant regardless of the speed at which it is operated. A steam locomotive, on the other hand, can develop its maximum horsepower at almost any speed, and its continuous tractive effort may be anything from its maximum, which is developed at starting, down to that necessary to give its maximum horsepower at its maximum speed. An electric locomotive designed to develop its continuous capacity at 60 mi. per hr., if operated in freight service at 30 mi. per hr. will be developing only one-half of its capacity. On account of the necessity of having the best riding qualities at high speed, the locomotive will be very much heavier than one designed especially for freight service having the same continuous tractive effort. The cost also will be much greater. It may be contended that where gearless motors are used, it is simply a matter of winding the motor to develop a given tractive effort at its maximum speed, and it will then be suitable for any service requiring this tractive effort at lower speeds. This is true, but for mechanical reasons the converse is not true; namely, that a freight locomotive can be operated in passenger service by winding the motors for a higher speed. An economical mechanical design for a locomotive, which is thoroughly satisfactory for freight service, will not be at all suitable for the high-speed passenger service. Steam locomotives have been used interchangeably to some extent in railway service, but in general this has been found impracticable.

TRANSMISSION FROM MOTOR TO WHEEL.—At the beginning of the paper it was stated that the transmission of power from the motor to the driving wheels is one of the most serious problems confronting the designer. It is closely allied with the type of framing, wheel base, and location of center of gravity of the locomotive. While many types of transmission are in successful operation, none is above criticism from some point of view.

GEARLESS CONCENTRIC MOTORS.—It is well known that gearless motors in which the armature is carried dead on the axle while having the simplest transmissions of all are destructive to roadbed when operated at high speeds. The mounting of the motor on a quill driving the wheels through springs is also objectionable from some standpoints, but it is open to less objection from the fact that its weight is all spring-supported against both vertical and lateral shocks.

There is a definite, though somewhat restricted, field where the gearless concentric motor is most successful. High service speed is essential to allow a rate of revolution sufficient to secure an economical power output per unit weight of motor. The gearless concentric motor for slow-speed operation cannot compete with the geared motor, as the weight and cost will be prohibitive. The power demanded per axle must not be so great as to result in wheel overloads.

Transmission Through Gears.

Gears are very unpopular in many quarters, and have unquestionably some disadvantages. However, there is probably no part of the standard street-car motor equipment which has given less trouble than the gears and pinions. There have been many cases of broken gears and of gears that have had an unduly short life, but all of these cases could be traced to a cause or causes which are now well understood, and can easily be avoided.

We feel perfectly safe in saying that, in the present state of the art, gears can be designed which will perform satisfactorily in any class of railway service. The improvements which have been made in the quality of gears and pinions by the use of high-grade materials having greater strength, higher elastic limits, and improved wearing qualities, are such that there should be no hesitancy on the part of the locomotive designer in recommending gears for service where a reduction from the armature speed is desirable, as in low-speed locomotives.

Gears for very slow-speed work may be pressed on the driving axle as in ordinary street car work. Where the motors are of large capacity, it will be necessary to use twin gears, as in the case of the locomotives for the Cascade Tunnel, and the high-speed freight locomotive No. 071 for the New York, New Haven & Hartford R. R. The former has the gears pressed directly on the axle, but in the latter, the gears are mounted on quills. This latter design is much to be preferred, and is in fact necessary where the locomotives are to be operated at speeds much above 30 miles per hour. The use of the quill, of course, involves a further connection between the quill and the driving wheels. This is accomplished in the case of the New Haven locomotive by long helical springs, one end of which is clamped to a projection from the quill and the other to the spoke of the driving wheels. (See Fig. 3.) These springs have such a large amplitude of motion that the axle is almost entirely unrestrained by the motor which is mounted rigidly on the truck framing. On this locomotive the gears are also provided with a spring connection between the rim of the gear and the center, which removes practically all of the shock due to high pitch line speed, and at the same time divides the load equally between the two gears on the quill.

A further advantage of gearing the motor to a quill having large clearance around the axle is that it enables the motor to be mounted rigidly on the truck, and directly above the axle, thus permitting the greatest economy of space by bringing the driving axles close together. It also raises the center of gravity of the springborne parts and brings the motor well above the dust and dirt of the roadbed. And as the motor projects through the floor into the cab, the commutator, brushes and oil boxes are rendered accessible at all times. It also facilitates the use of forced ventilation which greatly increases the capacity of motors of the enclosed type. The limitations of this type of transmission are not yet well defined, as it has been in use but a short time, but the performance thus far has been so satisfactory as to give promise of its success in a wide range of application. It is believed that on account of the extreme flexibility of the drive that the pitch line speed may be raised to a much higher value than has ever before been deemed possible. The flexibility effectually prevents the extreme shocks which are ordinarily received by the gear teeth of a high speed locomotive when the gear is pressed directly on the axle.

The use of gearing which permits the armature to run at a higher speed of rotation than the driving axle, places a limit on the speed of the locomotive which from the point of view of the operating man may be undesirable. It is necessary in designing such a locomotive to consider the maximum speed at which the locomotive is to be operated and leave a margin above this figure before the safe limit of the armature speed is reached. The service conditions will determine the maximum locomotive speed and also the speed at which the motors should develop their continuous-rating horsepower. These two locomotive speeds and the limiting peripheral speed of the armature, together with the desired horse-power output form the mechanical basis for the motor design. For economical designs it is not advisable to allow a maximum armature speed of more than 2 or 2.5 times the continuous rating speed. If a greater ratio than this is required, the armature speed must be reduced. The weight and cost of motor for a given continuous capacity will increase directly with this ratio.

Some of the other limits in a geared motor design are the pressure per inch width of gear face at the continuous rating, and the directly associated limit of the available distance between wheels, which must be divided between the gears and the motor. The available gear reduction is limited, on the one hand, by the diametral pitch necessary to secure a tooth with sufficient strength or life, together with the minimum number of teeth in the pinion consistent with low maintenance; and on the other hand, by the maximum number of teeth in the gear that can be applied with a given diameter of driving wheel with sufficient rail clearance.

With theoretically perfect gears a very high pitch-line speed should be operative. In regular interurban mounting of motors, heavy strains are imposed on gear teeth in high-speed operation by sudden vertical displacement of wheels due to track irregularities, with attendant acceleration or retardation of armature. In such applications a maximum pitch-line speed of 3,500 to 4,000 ft. per min. is operative. With complete spring support of motor and flexible connection to wheels, or with flexible gears, it is evident that a higher speed will be permissible. There are insufficient data at hand to approximate the limit under these conditions.

The above statements are all based on the use of spur gears and it is confidently expected that even better results can be obtained by the use of helical gears which are now coming into use. The success of this type of gear which is used for the Melville-McAlpin steam turbine drive indicates a sphere of usefulness for gears which has scarcely been touched.

While it is too early in the use of gears for large locomotives, to make an absolute statement of fact in regard to the allowable pressures, experience thus far indicates a pressure of 1,000 lbs. per inch width of gear face as a perfectly practicable value for continuous rating of large gears. With special steel pinions and high grade gears it is probably safe to exceed this figure. It is well known that for short hauls pressures far above 1,000 lbs. per inch are now in daily successful operation. In the locomotives for the St. Clair Tunnel, for instance, the pressure is carried on a single gear having a 6-in. width of face. The normal loads at which the locomotive operates on the up-grade give a pressure of from 1,500 to 2,000 lbs. per inch width of face on the gears. With this pressure the pinions have a life of 40,000 to 50,000 miles, and none of the gears has yet worn out, although the locomotives have been in continuous operation for over two years. With twin gears there is a possibility of further increase in unit pressure as the absence of relative skewing of pinion and gear shafts produces a better application of the tooth load.

Probably the greatest limitation to the use of motors geared to the axles or to quills surrounding the axles is the restricted space between the wheels. As the output of the motor increases the width of the gear face must increase also, and this extra gear space must be deducted from the space ordinarily occupied by the motor. This results in motors having a larger diameter than would ordinarily be designed. In spite of this limitation, however, it is probable that geared motors as large as 500 HP. continuous rating will be used. This is about as great an output as can be utilized on a single axle.

Transmission by Side Rods.

A desire to secure the good riding qualities of the high-speed steam locomotive, and at the same time to avoid the difficulties and limitations imposed by mounting the motor concentric with the axle, has led to the adoption of side rods for transmitting the power from the motor to the wheels. There is a very strong tendency in this direction both in Europe and in this country. The general form universally adopted except for the three-phase locomotives in Italy and Switzerland, which will be discussed separately, is that of the now familiar Pennsylvania locomotive which is illustrated by Fig. 6. The motor is mounted on top of the locomotive framing, and the armature shaft connected by quartered cranks to a jack-shaft located in the same plane as the driving axles. The power is transmitted from the jack-shaft to the wheels by parallel rods.

This type possesses some very distinct advantages. It permits the use of a single powerful motor to drive two axles. The motor is mounted in the cab instead of under it so that all parts are readily accessible and are thoroughly protected from the dust, dirt and water from the roadbed. The location of the heavy motor so high in the cab raises the center of gravity of the locomotive to a height corresponding to that of high-speed steam locomotives. The side rods form a transmission system that is familiar to all steam locomotive operators. It apparently has all the good points of the steam locomotive rods and is, in addition, susceptible of perfect mechanical balance and gives a uniform tractive effort.

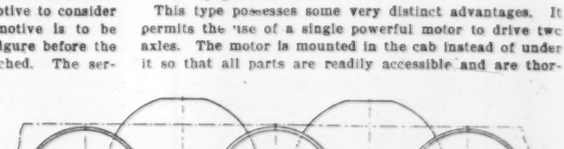

FIG. 10. VALTELLINA RY. SCOTCH YOKES AND SIDE RODS.

There are, however, certain fundamental differences between the performances of side rods on steam and electric locomotives.

(1) The steam locomotive transforms the heat energy of the steam into mechanical work by means of a reciprocating engine. Connecting rods and cranks are therefore essential features. The electric locomotive on the other hand develops its power by rotation and no single type of transmission can be listed as indispensable.

(2) In case of a steam locomotive there are at least two independent sources of mechanical forces, viz., the cylinders. Each piston constitutes a "free end" of the transmission system. The distance from the center of cylinder to the center of main driver axle is not a hard and fast value, as a slight variation means only a change of crosshead overrun and of cylinder clearances. In an electric locomotive where there is a single motor, crank and rod connected to a countershaft, there are no "free ends" to the system. For this reason great accuracy of tram and parallelism of motor shaft and countershaft are essential, any error being accompanied by serious stresses in the transmission with associated low mechanical efficiency and high maintenance charge, especially for bearing brasses.

(3) In the steam engine the stresses on the transmission system at any point in the cycle can be very closely approximated by means of indicator cards taken from the cylinder, together with centrifugal stresses. In other words, each side of the engine can be considered separately. With the electric locomotive on the other hand, there is but one source of mechanical force—the motor which exerts a constant turning moment or torque throughout the entire revolution. This constant torque must be transmitted to the driving axle without modification except for the losses in bearings. At certain points in the cycle all the torque of the motors is transmitted through one crank; at certain other points it is transmitted through the opposite crank. At intermediate points it may or may not be transmitted through a single crank, as the interchange of work is different in different machines, being a composite function of journal and pin clearances together with bending and torsional deflections of all elements of the transmission and framing. It is therefore not possible to analyze the forces on one side of the locomotive independently of the other side.

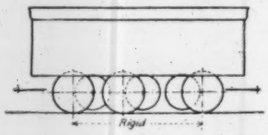

Fig. 11. St. Clair Tunnel. Cab and Framing Integral. Rigid Base.

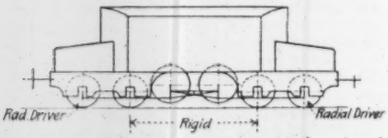

Fig. 12. Simplon Tunnel. Cab and Framing Integral. Rigid Base With Radial Drivers.

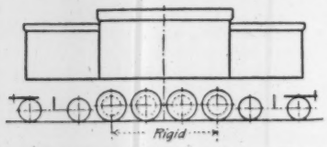

Fig. 13. New York Central. Cab and Framing Integral. Rigid Base With Guide Wheels.

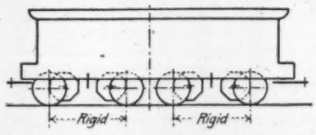

Fig. 14. Early Pennsylvania R. R. Cab and Framing Separate. Two Rigid Trucks.

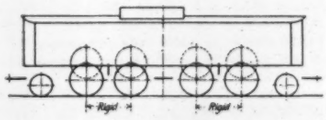

Fig. 15. New Haven. Cab and Framing Separate. Leading Wheels.

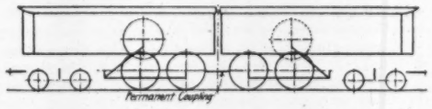

Fig. 16. Pennsylvania. Articulated.

FIGS. 11 TO 16. FRAMING AND WHEEL ARRANGEMENTS OF ELECTRIC LOCOMOTIVES.

(4) In the steam locomotive the main rod connects the cross head to the drive wheels. In the electric, all the driving effort is transmitted through four running pins in series before any useful work is performed. This results in considerable loss of mechanical efficiency. It may be noted that the use of knuckle pins would avoid one or possibly two of the running pins mentioned but thus far no railway operator has been found in this country who is willing to accept knuckle pins in an electric locomotive. Knuckle pins have caused so much trouble from breakage that they will have to be modified considerably before they will be acceptable. The trouble seems to lie in the twisting of the rods due to uneven track.

The side-rod type of locomotive is at a disadvantage when compared with the high-speed geared type described, because of the fact that the mechanical parts of the locomotive and also the motor frames must necessarily be much heavier to withstand the reciprocating stresses imposed on them. They will also require much more careful work in assembling and will therefore be more expensive. On the other hand, it would seem that after the side-rod locomotive is once completed, the mechanical parts should be very cheap to maintain. The results of the operation of the Pennsylvania locomotives will be awaited with great interest.

SCOTCH-YOKE SIDE-ROD TYPE.—The type of drive which has been used to the greatest extent with the three-phase locomotives in Italy is that illustrated in Fig. 9, utilizing the so-called "Scotch Yoke" for connecting the motors with the driving wheels. This has been in use for several years and has apparently given excellent results. In these machines much of the criticism attendant upon connecting rod applications has been obviated. The motors, being flexibly attached to the springborne parts, are not subject to severe cranking strains and can therefore be made light mechanically. The motor shafts, it is true, should line and tram accurately but they are so located that this can be done with minimum difficulty. The mechanical parts also can be made considerably lighter because of the fact that there is no jack-shaft required, and the cranking strains are taken directly on the armature shafts which are supported in bearings in the side frames. The design, however, sacrifices high center of gravity, and some alternate plan for securing easy riding qualities must be adopted. One which has been suggested utilizes a plan somewhat in line with that suggested for the gearless concentric motors; namely, having springs between the motor and side frames for cushioning lateral shocks. The mechanical efficiency of this type should be higher than that of the rod-connected design, because of the fact that the power is not transmitted through so many running pins. It has the objectionable feature of a sliding connection between the driving yoke and the pin on the middle driving wheel, but this apparently causes no trouble whatever. In fact, the locomotives as observed on the Valtellina Railway operate smoothly, and apparently with small friction loss. This may be ascribed in part to the fact that all bearings are kept flooded with oil. The use of knuckle pins for transmitting power from the "Scotch Yoke" to the outer driving wheels is made perfectly safe by the use of spherical pins or spherical bearings.

This type of drive will give probably a lighter locomotive than is possible with any other drive having motors operating at the same speed as the driving axles. It has thus far not met with favor in this country, but its merits will undoubtedly bring it into use for moderate speed work where gearless motors are desired.

COMBINATION GEAR AND CONNECTING ROD DRIVE.—Where slower speeds are desired than can be secured by the use of motors operating at the same speed as the axles it is sometimes more economical to use two motors geared to jackshafts and connected to the drivers by means of the "Scotch Yoke" in the same way as just described. Fig. 9. This scheme has some advantageous features which are not at first apparent. It permits the use of large motors and gives much greater space for them than can be secured between the drive wheels where the motors are geared either to the axles or to quills surrounding the axles. The motor is mounted so that its center of gravity is high, and as it extends through the floor into the cab, the bearings and brushes are easily accessible. In this respect the motor has all of the advantages possessed by the rod-connected motor. Gears can be located outside of the driving wheel so that they can be replaced without dismantling the locomotive any further than required by the removal of the side rods. Locomotives involving this principle have been built in Europe, and a large one is now under construction for the Midi Ry. in France. As stated before, it is especially fitted for work where it is desirable to reduce the number of motors to a minimum and at the same time operate at slow speeds with heavy tractive efforts.

This locomotive, however, is subject to such criticism as is involved in synchronous revolution of many parts with a consequent loss in efficiency and with possible inertia complications. In this respect it is practically on a par with all rod-connected locomotives.

ROD-CONNECTED LOCOMOTIVE WITH RADIAL AXLE.—A description of the principal types of transmission would scarcely be complete without mention of the three-phase locomotives now in use in the Simplon Tunnel. The chief point of interest lies in the location of the motors, the connection to the drivers, and the radial driving wheels at the ends of the locomotive. The motors are located as close together at the middle of the locomotive as possible, and their crank pins are connected together by a frame. From pins on this frame on a line with the center of the axles, rods are carried to the nearest driving wheels, and thence other rods connected to the axles of the outer drivers, there being four pairs of driving wheels. It is, of course, essential where side rods are used that all axles should remain substantially parallel, and in order to secure the radial motion of the wheels at the ends of the locomotives, it is necessary to mount the wheels on quills which surround the axles and connect them together only at the middle point by a kind of universal joint. By these means the wheels are able to move in a radial direction, while the axles which drive them are kept parallel to the inside driving axles. This seems to be operating very satisfactorily, and with some modifications will probably meet other conditions where all the weight is carried on the drivers, and a rigid frame locomotive with flexible wheel base is required.

Cupro-Nickel-Steel.*

By G. H. CLAMER.†

A systematic study of the properties and constitution of a complete series of alloys presents a most interesting field of research. It has only been within the past comparatively few years that methods have been devised for the proper study of the constitution of alloys, and by means of which a better understanding of the properties is to be gained. Practically all the binary alloys have been studied up to the present time, at least of all the more important metals, but the constitution of the ternary and quaternary combinations presents an almost endless field for research. The study of the combination of metals to form alloys is particularly interesting because the results obtained are often most surprising and least expected, and even with our present knowledge are unexplainable and quite the reverse of what might be predicted. A few examples of the surprising results due to the combination of metals to form alloys, are as follows:

1. Magnetic properties of certain alloys of manganese with aluminum, two metals having no magnetic properties.

2. Extremely high melting point of certain alloys of antimony and aluminum, two metals of comparative low melting point.

3. Disintegration of certain alloys of iron and aluminum, nickel and aluminum and manganese and aluminum, which disintegrate after some months' standing and actually fall to powder.

4. The surprising ductility of certain ternary alloys, which result from the addition of two metals in combination with a third, in such proportions, that were either of them added separately in proportions in which they exist in ternary alloy, there would result an alloy which is quite brittle. The alloy particularly referred to was discovered by Sir Robert A. Hadfield, and described by him in the Iron and Steel Institute, 1905. It is of the following composition:

Carbon	0.6%
Manganese	5.04%
Nickel	14.55%

This steel has an ultimate strength of 60 tons and elongation of, 70%.

One of the series of alloys which I am about to describe in this paper is an alloy of this nature. It has copper present in such proportions, that were it added alone to the steel, would render it exceedingly brittle, i. e., such a steel would have practically no elongation whatever, whereas, with the joint addition of nickel there results an alloy of high ductility. Before describing this alloy, it would probably be well to review the results of various investigators who have studied the binary alloys of iron and nickel and iron and copper, both with and without carbon. The iron-nickel alloys may apparently be divided into three classes:

1. Those containing less than 8% nickel which have a pearlitic structure.

2. Those containing from 8 to approximately 25% nickel which have a martensitic structure.

3. Those above 25%, which have a crystalline structure.

These proportions, however, are not absolutely fixed, but are dependent to a great extent upon the carbon content, transitions taking place at lower percentages of nickel with higher percentages of carbon.

Messrs. Chas. Burgess and James Aston, of the University of Wisconsin, recently investigated the complete series of nickel alloys with electrolytic iron of high purity, so that the effect of the alloying metal was

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†Second Vice-Pres., Ajax Metal Co., Philadelphia, Pa.

due to nickel alone and not to some combined influence which might result from the use of more impure material, by which they confirmed the existence of these three ranges in the constitution of nickel-iron alloys. The effect of the nickel on the iron, as they describe it, was as follows:

1. To increase the strength with a slight decrease of ductility in the range of lower nickel content.
2. Beyond this range the addition of nickel causes a sudden increase of strength which causes a marked decrease of ductility over a zone of decided brittleness.
3. The position of the brittle zone varies with the carbon content and probably with a variation in the other impurities, such as manganese, if present in appreciable amounts. For a pure alloy, where the effect is due to nickel alone, the area may be set between 10% and 16% of nickel. The addition of carbon places the zone at lower percentages of nickel, beginning in the neighborhood of about 10% for carbon = 0.22% and at about 7% nickel for carbon = 0.82%, where the other impurities are small. It may commence as low as 5% nickel in medium carbon steels (C = 0.44) where the manganese rises to 1%. Accompanying this brittleness, there is a marked hardening in the material.
4. Annealing while not greatly affecting the region of the brittle zone or the extent of the brittleness, has a tendency to confine the range to more narrow limits.
5. For percentages of nickel above those of the zone of brittleness there is a restoration of the ductility and softness.

The iron-copper alloys have also been investigated quite thoroughly by a number of investigators, but with very conflicting results, which were no doubt due to the influence of carbon in the alloys under investigation. It was formerly thought that iron and copper would not alloy, except in very small proportions of one with the other, but it has now been thoroughly demonstrated that the extent to which copper will alloy with iron is dependent entirely upon the carbon content. Carbonless iron and pure copper will mix in all proportions, and will not separate into two conjugate layers in the cast ingot. Stead has shown that the complete series of copper-iron alloys, according to their constitution, may be classed into three distinct series, i. e.,

1. Alloys with trace up to 2.73% iron, 97.2% copper.
2. Alloys between 2.73% iron, 97.2% copper and 92% iron and 8% copper.
3. Alloys between 8% and trace of copper.

The first class is quite homogeneous, consisting of but one structural constituent. The second class consists of two structural constituents. The third class also has but one structural constituent, which, however, is made up of crystals which are richer in copper in last portion to solidify.

The properties of these copper-iron alloys have also been recently investigated by Messrs. Burgess & Aston, and they have found that additions of copper up to 8% causes increase in ultimate strength and diminution in ductility, and alloy with 8% having no ductility whatever. As a result of this valuable research, they have recommended for commercial use, the alloy with 1½% copper, this alloy having very much the same properties as nickel-steel with 3½% nickel. Still it must be remembered that this alloy was made from practically carbonless iron, and therefore, would no doubt present some practical difficulties in its manufacture.

I have reviewed these iron-nickel and iron-copper series of alloys, in order to show, as I have stated before, what surprising results are obtained by the joint addition of copper and nickel, i. e., alloys can be produced carrying from 5 to 20% copper, which without nickel would be extremely hard, brittle and red short, but these become, by the addition of nickel in proportion of 20 to 50%, highly ductile, easily forgeable and easily machineable. Such alloys are capable of being rolled into sheets or rods, and can be machined without difficulty, in fact they are quite soft.

The following are tests of two typical alloys within these ranges of proportions:

	No. 1.	No. 2.
Copper	9.00%	19.50%
Nickel	22.00%	45.00%
Carbon	0.22%	0.2 %
Ultimate strength	101,000 lbs.	92,230 lbs.
Elastic limit	57,300 lbs.	54,150 lbs.
Elongation	42.5%	35%
Reduction of area	61.5%	47.9%

These tests were made on rolled rods. The elastic limit, it will be noted, is quite low in proportion to the ultimate strength, which naturally accounts for their softness. Alloys at the lower range of the series can be bent cold to an angle of 180° without fracture, whereas those at the higher end of the series cannot be bent so far. Alloys at the lower end of the series will resist corrosion in a highly satisfactory manner, and those at the upper end are practically non-rusting. Samples which have been exposed for the past year in contact with concentrated foundry gases, and at Atlantic City in contact with salt atmosphere, have demonstrated these facts. In addition to this, the alloys have a very low coefficient of expansion. Just what use such alloys might be put to has not yet been determined, but no doubt quite a number will suggest themselves, i. e., as a substitute for the present 25 to 35% nickel-steels, and probably quite a number of others, because the steel can be produced at a very much lower cost, not only because of the substitution of copper for nickel (copper selling at the present time at less than one-third the price of nickel) but because the alloy can be made from Monel Metal, a commercial alloy of copper and nickel, containing copper and nickel in correct proportions for making such a steel. Monel Metal sells for about the price of copper. It is also possible to make the steel directly from Sudbury nickel ores, by simply smelting and bessemerizing to eliminate the iron to extent desired, roasting the matte produced, and finally reducing the combined oxides resulting from roasting the matte. It is thought that either by the use of Monel Metal for making the steel alloy or by the direct production of it from the ore, that the cost of production might be sufficiently reduced to make it attractive for roofing, gutters, spouts, ventilators, and many other uses where its resistance to corrosion and its low coefficient of expansion will warrant the cost. Such sheets can be produced to sell at a very much lower price than copper, and probably two to four times the price of commercial coated iron and steel sheets, but as the alloy is about twice as strong as the soft steel and about three times as strong as copper sheets, thinner gages can be used. The alloys at the higher end of the series, as I have said before, are non-rusting.

Steels within this range of proportions of copper and nickel have a crystalline structure such as is possessed by nickel steels carrying above approximately 25% nickel or with somewhat lower percentage of nickel, if carbon is present in appreciable amount, in other words, nickel-steel within the crystalline range, the copper apparently acting very much like nickel. It will be noted that the physical properties are very similar to those of the same nickel-steels without copper.

Noting the curious and unexpected results obtained with these high copper-nickel alloys, I became curious to know what would be the effect of replacing part of the nickel in nickel-steel within the pearlitic range by copper, and accordingly made such steels with from 1 to 8% Monel Metal, in which the proportion of nickel to copper is roughly 2½% nickel and 1% copper, and here again the copper really acts like so much nickel, at least when present in these relative proportions, and it is possible, therefore, to produce a steel of practically the same physical properties as nickel-steel, at very much reduced cost. In these steels, the nickel, iron and copper are in the same relative proportions in which they exist in some of the prominent mines at Sudbury, where vast deposits exist, average analysis of these ores being as follows:

Copper	0.8 to 2.0
Nickel	2.0 to 5.0
Iron	35.0 to 52.0
Sulphur	Balance
Gangue	

It will be seen by the operation of reducing this ore to matte, calcining the metal to remove the sulphur, and reducing the calcined product that this steel can be produced almost to the most desired formula. The valuable properties of the nickel-steel, i. e., carrying below 6% nickel, have of course long been recognized and recently the value of copper as a valuable constituent of steel, instead of a metal to be looked upon as a detrimental impurity, has also become recognized. It is probably not quite so surprising therefore, that the joint addition of copper and nickel within this range of proportions is productive of valuable results. The addition of these two metals in combination seem to have the same effect upon the steel as if they were individually added, the copper in its effect really being about the same as so much added nickel. It is possible, therefore, to replace part of the nickel in nickel-steel by copper, without materially altering the physical properties. The following table gives the physical properties of some of these alloys:

	Monel metal, %	Carbon, %	Ult. strength, lbs.	Elast. limit, lbs.	Elongation, %	Red. %
No. 1	4	0.11	83,600	66,300	26.5	65.4
No. 2	3	0.10	75,300	64,600	25.5	71.4
No. 3	2	0.15	75,500	63,700	28.0	65.4
No. 4	4	0.61	151,000	120,000	8.0	13.8

Recently Messrs. Aston & Burgess, working quite independently of me, have confirmed these results with alloys which they have made with electrolytic iron, which has been quite gratifying, and although I have not had an opportunity to study all the properties of the complete series of alloys within these ranges, i. e., pearlitic and crystalline, nevertheless, it would seem from the tests of alloys so far made, that these alloys may become of commercial value, especially as we now have at hand a comparatively cheap alloy from which they can be produced, i. e., Monel Metal, and the further possibility of producing them directly from Sudbury ores.

Discussion of Cupro-Nickel-Steels.

By JOHN A. MATHEWS.*

So far as I recall, none of the Society's specifications mention copper at all; however, I find that there is still in the minds of many users of steel a prejudice against copper.

A year or two ago we sent a large quantity of sprung steel to the Panama Canal. Upon its receipt we were advised that the copper content exceeded the specification and it was reported as being from 0.07 to 0.12, whereas the specification had stated that the steel was subject to rejection if the copper exceeded 0.05. Our own analyses confirmed the fact that the copper was higher in the steel than we had expected but the writer looked up the authorities on the subject and presented such an eloquent and convincing brief that not only was the steel accepted but specifications since that time have omitted any reference to the copper content.

In connection with nickel steel a firm of automobile manufacturers formerly specified that the copper in their nickel steel should not exceed 0.025. The writer was instrumental in getting this specification changed so that the user shifted the decimal point for copper one point to the right making the permissible amount 0.25 and still later omitted all mention of copper in his specification.

It is, perhaps, a surprise to many to know how generally present copper is in all kinds of steel, even in the best grades of Swedish materials. Bischoff published the analyses of some 40 or 50 samples of German and Swedish steels and every one of them contained copper, the amounts varying from mere traces up to 0.274. It is sufficient to say, however, that the general trend of scientific work in connection with the influence of copper on steel has been to show that, in any ordinary quantities in which it is likely to be found, its effect is not marked one way or the other, or may even be beneficial.

The particular experiment in reference to cupro-nickel-steel to which I should like to refer is of perhaps more than ordinary interest owing to the fact that the heat of nicked steel containing copper was melted in our Heroult electric furnace and that pig iron used in this heat was produced in Canada in the Heroult smelting furnaces which were installed there some years ago, that is, the entire heating from the ore to the finished product, was by means of electricity and this is probably the first heat of steel so made in the United States. The pig iron, as produced from certain of the Canadian ores, carries a considerable amount of nickel and copper and it was with a view to seeing what results could be obtained from this pig iron that we made a cold heat, charging in cold pig and ore into our furnace. The result of this heat gave steel of the following analysis:

Carbon	0.44 %
Silicon	0.034%
Manganese	0.50 %
Phosphorus	0.013%
Sulphur	0.013%
Nickel	3.62 %
Copper	0.48 %

It must be remembered that all the nickel and copper present were contained in the original pig iron used. We had no definite analysis in mind when we started this heat, but were more interested in finding what grade of steel would result from the grade of pig used. The ingots were clean and worked very satisfactorily under the hammer and the 0.5% of copper present seems to have exerted no deleterious influence as regards the heating or working.

For the sake of comparing this steel with another steel of approximately the same analysis but free from copper, we have selected an open-hearth nickel steel whose heat analysis was as follows:

Carbon	0.46 %
Silicon	0.068%
Manganese	0.70 %
Phosphorus	0.021%
Sulphur	0.034%
Nickel	3.36 %

An examination of this heat showed that it also contained about 0.1% copper. The physical tests to be mentioned later were made from ¾-in. diameter round bars and the greatest care was used in their heat treatment. Tests were made in duplicate and the annealing of the bars from the two heats were made at the same time so as to avoid any possible difference in the annealing temperature. It was noted that the open-hearth steel machined a little more freely than the electric furnace nickel steel containing 0.5% of copper, but here the superiority ended. The tensile tests of the material as rolled gave us the following figures:

	O. H. Nickel.	Cupro-Nickel.
Elastic limit	74,625 lbs.	72,400 lbs.
Ultimate strength	122,000 lbs.	113,000 lbs.
Elongation in 2"	16%	22%
Reduction in area	34%	51%

In the annealed condition the physical tests were as follows:

	O. H. Nickel.	Cupro-Nickel.
Elastic limit	64,750 lbs.	63,750 lbs.
Tensile strength	119,000 lbs.	107,300 lbs.
Elongation in 2"	17%	25%
Reduction in area	37.5%	48%

Samples of both steels were heated to 1,500° F., quenched in oil and drawn back to a temperature of 800° F., and maintained at that temperature for 20 mins. In this condition, the results of physical tests were as follows:

	O. H. Nickel.	Cupro-Nickel.
Elastic limit	154,500 lbs.	154,000 lbs.
Tensile strength	175,000 lbs.	172,500 lbs.
Elongation in 2"	9.75%	13.25%
Reduction in area	30.8 %	49.1 %

*Genl. Supt., Halcomb Steel Co., Syracuse, N. Y.

In all the tests above, the elastic limits and tensile strengths are not very different for the two steels but the very great superiority of the cupro-nickel steel in the elongation and reduction of area is most noticeable. The presence of the copper certainly has not in any way decreased the toughness of the steel, as manifested in its elongation and reduction of area, but the most remarkable difference in the two steels was noticed in samples which had been quenched as before at 1,500° F. and drawn back to only 600° F. In this condition, both steels showed an elastic limit of about 185,000 lbs., with the tensile strength slightly above 200,000 lbs., but, whereas the open-hearth steel was decidedly brittle by this treatment, only giving 2% elongation and 4% reduction in area, the electric furnace product gave 12% elongation and 46% reduction in area.

So far as this single test is concerned, therefore, there is absolutely no evidence to show that the copper has exerted a harmful influence upon the nickel steel, and we must either ascribe its superiority to the presence of copper, or to the superiority of the electric method of melting, or to both acting jointly.

From an extended experience with electric furnace product as compared with the open-hearth nickel steels in carbons varying from 0.10 up to 0.50, there no longer remains any doubt in my mind as to the superiority of the electric product over open-hearth nickel steel.

A Proposed Method for Raising the "Maine" from Havana Harbor.

In the session of the federal Congress just adjourned two bills were passed appropriating first $100,000 and then $200,000 additional to be expended under the direction of the Engineer Department of the U. S. Army in raising the wreck of the U. S. battleship "Maine" from her 12-year old berth in the bottom of Havana Harbor. Owing to clerical inconsistencies in the second of these two bills, there at first was some doubt in the minds of the officials at Washington as to the legality of the $200,000 appropriation, but the Attorney General, after examination of the matter, reported that the whole $300,000 is now available. Meanwhile the Chief of Engineers, Gen. W. H. Bixby, has under consideration a number of schemes for the raising of the ship and some definite plan will soon be adopted for the prosecution of the work.

Among the plans which have been submitted, one of the most practicable is that devised by Mr. John F. O'Rourke, M. Am. Soc. C. E., New York City, the well-known foundation and tunnel engineer. Mr. O'Rourke has had his idea patented and proposes to undertake the work for the government under the general direction of the army engineers but with the force and equipment of the company of which he is president. In the present article we are able to present the outlines of the plan and the details of the apparatus to be used.

The U. S. Battleship "Maine" was sunk in about 35 ft. of water at her moorings in Havana Harbor on Feb. 15, 1898, as a result of an explosion at the forward part of her hull. This explosion tore away the entire forward section of the vessel but left the remainder intact and in that portion are still the bodies of some 200 of the crew who were drowned when the ship went down. The fact that the forward portion is so completely wrecked makes extremely difficult any method of raising which involves the filling of the hull with compressed air and makes some style of coffer-dam pontoon or adjacent raising device almost necessary in the raising. The first style of salvage operation, in fact, is the only one which heretofore has been given much publicity in this particular wreck and was quite fully described in Engineering News, Dec. 8, 1904, p. 520. At that time a company was formed which proposed to drive around the wreck a specially designed circular bi-walled coffer-dam, to pump out the dam and in the dry area to make the ship seaworthy. The scheme however never got far beyond the design stage. The pontoon scheme is complicated by the necessity [illegible] helmet-divers work. The third scheme, that [illegible] adjacent solid docks from which the lifting [illegible] ations may be carried on is the basis of Mr.

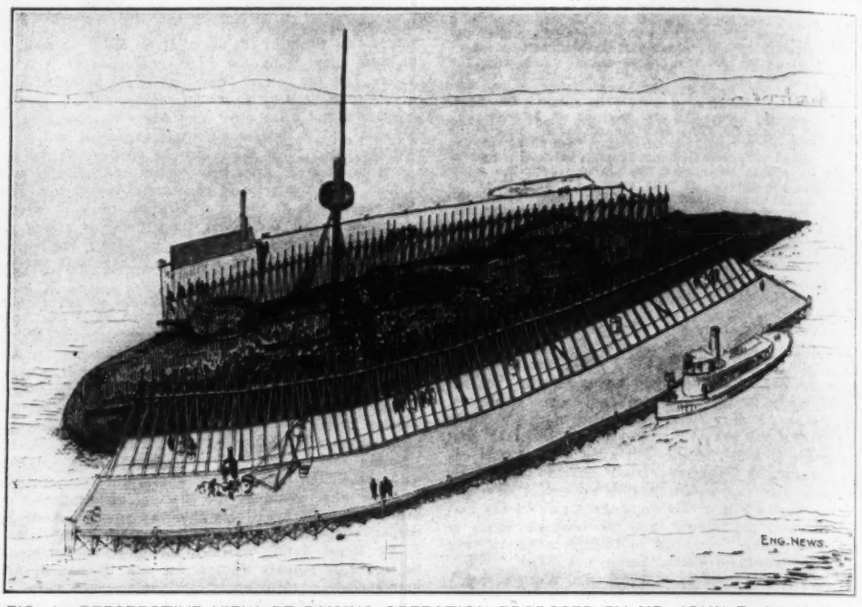

FIG. 1. PERSPECTIVE VIEW OF RAISING OPERATION PROPOSED BY MR. JOHN F. O'ROURKE, M. AM. SOC. C. E., TO RAISE THE "MAINE."

O'Rourke's idea, though the use of pneumatic caissons is the fundamental feature of the scheme.

The water at the site of the wreck is about 35 ft. deep and overlies a soft muddy bottom into which the hull has sunk another 10 ft., and only the upper works now stick up above the water surface. Havana Harbor is remarkably well protected and there is only about a 10-in. range of tide with hardly any wind or wave action, so that any operation such as will be required by Mr. O'Rourke's scheme will not be hampered by bad weather conditions.

In brief Mr. O'Rourke's scheme consists in raising the "Maine" on a cradle of cables, slung under the ship by means of laterally placed pneumatic caissons and carried from derricks resting on the top of these caissons. The accompanying illustrations will help the understanding of the following description. The first step will be to drive on either side of the wreck and about 20 ft. away from it, an ordinary pile and timber dock founded on straight and battered piles driven, as shown in Fig. 3, well down into the soft mud bottom of the harbor. These docks are to be some 40 ft. wide so that their outside edges will be about 60 ft. away from the sides of the vessel. The docks once built, there will be sunk in the space between each dock and the vessel a series of timber compressed-air caissons, each 15 × 40 ft. in plan. These caissons are to be sunk side by side, as drawn in the plan in Fig. 2, as near together as is possible and also as near to the side of the wreck as various projections thereon will permit. As at present designed there are to be six of these

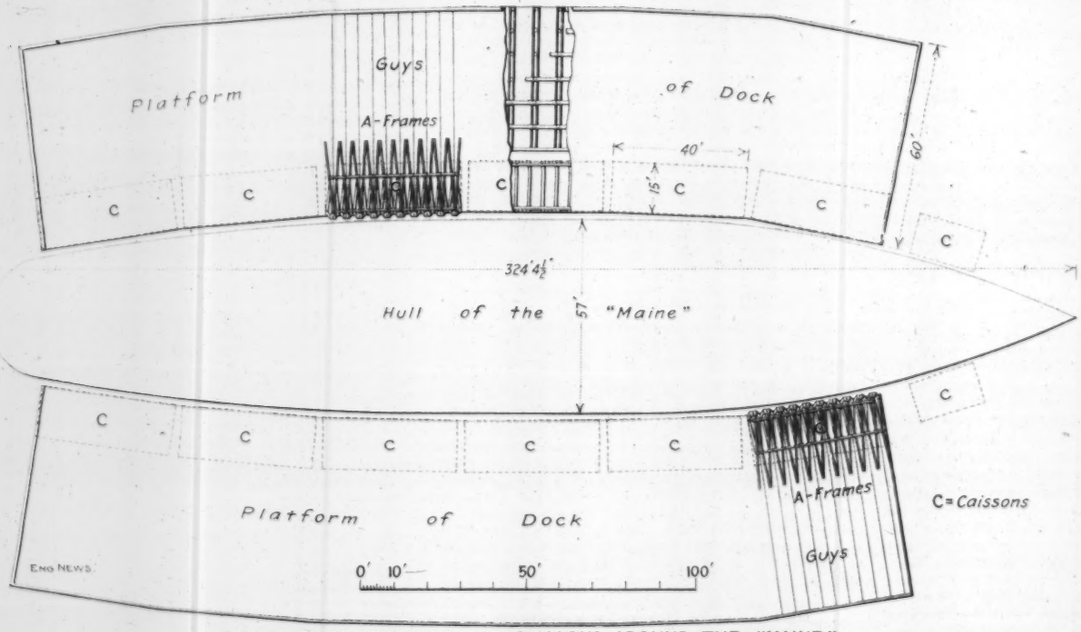

FIG. 2. PLAN OF DOCKS AND CAISSONS AROUND THE "MAINE."

caissons on each side, extending up to within some 60 ft. of the bow of the vessel. On account of the twisted and torn condition of the ship's framework at this end it is thought useless to attempt to continue the raising apparatus any farther forward, but in case it is found, after

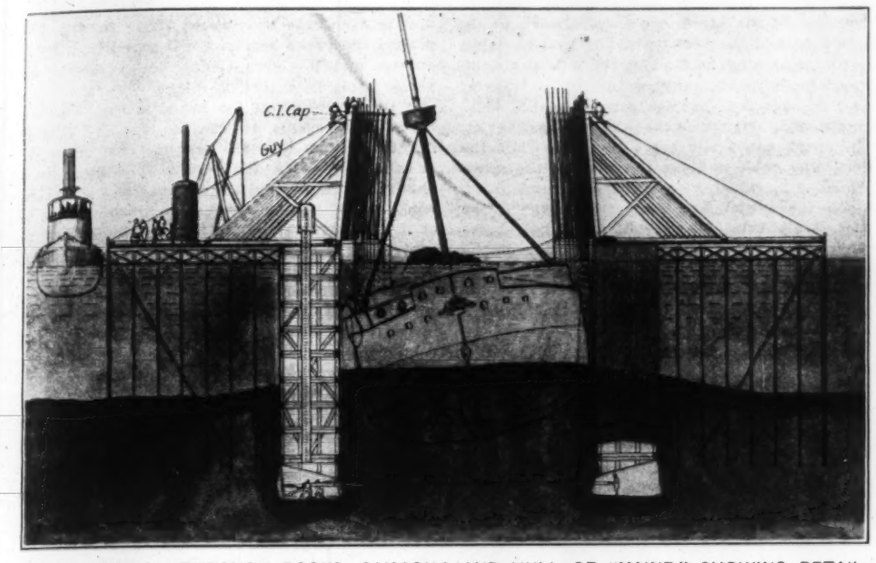

FIG. 3. SECTION THROUGH DOCKS, CAISSONS AND HULL OF "MAINE," SHOWING DETAIL OF RAISING DEVICE.

work has commenced, that such a continuation is desirable, it will be a simple matter to sink extra caissons near this portion of the wreck.

The caissons are to be of the ordinary lapped timber construction, as shown in the section in Fig. 3, and are to be made extra strong for load transmission, as the thorough cross-bracing will indicate. They are to be made watertight so that they can be pumped dry, to the chamber ceiling, but they are to be filled with water at the beginning of the operation, for reasons explained below. The caissons are built with the outer cutting edge higher than the inside to keep the escaping compressed air away from the vessel, which would otherwise be disturbed and further sunk in the mud. As the bottom of the wreck is about 10 ft. below the present harbor bottom, the caissons will be sunk some 10 ft. farther so as to make certain that their bottoms are well below the lowest part of the sunken framework. When the caissons are driven to their required depth, the dock is to be continued straight across their tops up to the side of the wreck and is to be used as the working platform from which to conduct all operations. On the outside face of the caissons toward the wreck there will be hung in vertical lines and spaced about every 4 ft. longitudinally, a number of wire cables stapled lightly to the wooden framing of the caisson and coiled at the upper end on the caisson top, with the lower end passing under the driving edge of the caisson and coiled in the working chamber. On one side there are to be ¾-in. steel cables such as are ordinarily used in construction work and on the other they are to be at least of 2-in. plough-steel with an ultimate loading capacity of 400,000 lbs.

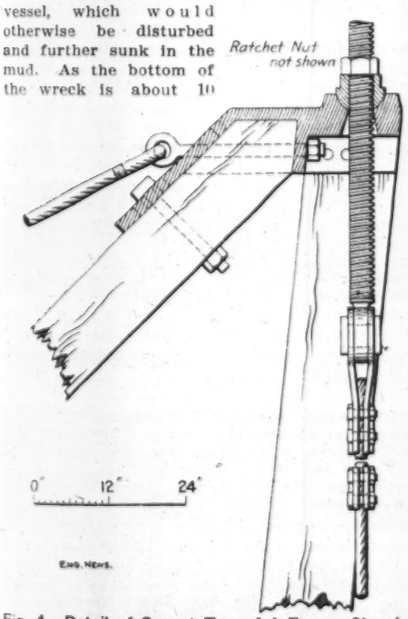

Fig. 4. Detail of Cap at Top of A-Frame, Showing Screw Device.

We can now imagine the caissons sunk to their proper elevation. At every 4 ft. along the inner face of the left-hand set (Fig. 2) is a ¾-in. cable coiled on top of the dock, passing down the side of the caisson, under its cutting edge into the working chamber where it hangs coiled. On the right-hand set of caissons hang 2-in. cables arranged in the same manner. Now in the opening below the working chamber below the left-hand caisson, a 3-in. wrought-iron, inside-coupled pipe is driven out into the mud, which will stand against the air pressure from the chamber, toward the opposite or right-hand caisson. Gradually, section by section this pipe is driven over until it penetrates the working chamber of the opposite caisson. Into this pipe is then led the end of the ¾-in. cable coiled in the left-hand working chamber, as a pilot cable which is to connect the two working chambers. Now, from the right-hand caisson the 3-in. pipe is drawn in, section after section removed and slipped over the connecting cable, until finally the whole pipe is taken in and the two chambers are connected only by cable through the intervening mud.

Now, the end of the ¾-in. cable in the right-hand chamber is spliced to the 2-in. cable hanging there and, by tension applied at the upper end of the ¾-in. cable at the top of the left-hand caisson, the two cables are gradually pulled up toward the bottom of the ship. First the bights around the driving edges are pulled out, then the light staples holding the cables to the caisson faces, and then the cable is pulled through the soft mud up tight against the bottom of the wreck. Pulling is continued until the 2-in. cable appears on the left-hand dock and has thus passed completely under the ship. This process is repeated for each of the cables, spaced every 4 ft., until finally there would be about 60 of these cables passing under the ship, snug up against its bottom and held securely on the solid dock on either side.

There now remains to design some method of tackle whereby these cables may be simultaneously tightened and raised bringing, as they must if they are raised, the hulk up from the muddy bottom with them. The tackle as now designed is shown on the section in Fig. 3 and in detail in Fig. 4. It consists primarily of an A-frame above each of the cables, with the main mast footing on the inside wall of the caisson and with the bracing leg and the guy ropes carrying back to the dock proper. At the top of each frame is a cast-iron cap such as is shown in the detail design in Fig. 4 carrying a jack-screw system by means of which the lifting is to be done.

The jack-screws are designed to lift more than 100 tons and the bottom end is formed of an eye-bar like that of a bridge truss, while the clamp which grips the cable ends in two similar eye-bars into which the screw is fastened with a 3½-in. steel pin (Fig. 6). This screw passes up through the cast-iron cap and is provided with a ratchet-headed nut by means of which the screw is operated. In order to provide universal motion to care for the necessary movement in the cable and also to prevent the cable from twisting during its raising a special saddle or head has been designed for the cap. Primarily this consists of an oval cup-shaped indentation in the upper face of the cap into which fits a similarly shaped saddle, provided with a 3 9-16-in. opening through which the 3½-in. screw passes and provided further with a flat side against which the flattened side of the lifting screw sets. The oval-shaped opening allows universal motion without twisting in a horizontal plane and the flattened screw prevents the screw from turning when raising.

The method of raising the wreck has been worked out as follows: As soon as the cables are taut under the ship but before any weight has been put upon them, the working chambers of the caissons will be filled tight with sand so as to give an even and solid bearing of the caisson on the mud bottom and then the caissons will be pumped down to such a depth that the weight of water removed will nearly equal the weight of the hulk. In this way no weight will be placed on the mud at the bottom of the caissons greater than that on them during their sinking. This water having been removed, pipes carrying compressed air or water under pressure will be forced down along the sides of the hull of the "Maine" in order to loosen the 12-year hold that the harbor mud has taken on the bottom and side plates of the wreck. This grip having been loosened the lifting operation can commence.

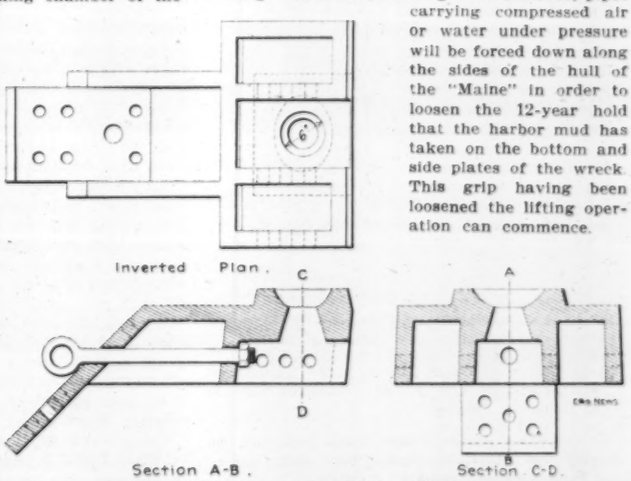

FIG. 5. DETAILS OF UNIVERSAL JOINT CAP.

First, the screws will be operated locally in such places as to raise the vessel to a horizontal position, both laterally and transversely, for she has settled on one side and down by the head. When this is done the screws are all at different

levels. As there is a large excess of strength in the cables and lifting apparatus, one or more pairs of screws are slacked off and the screws fleeted down their full length and then tensioned as before. This is repeated with all the cables until they are all ready for a full lift. Then the real lifting operation will commence. Mr. O'Rourke plans that about 1,000 men will be needed to man the jacks and suggests that the government detail a regiment of the army for

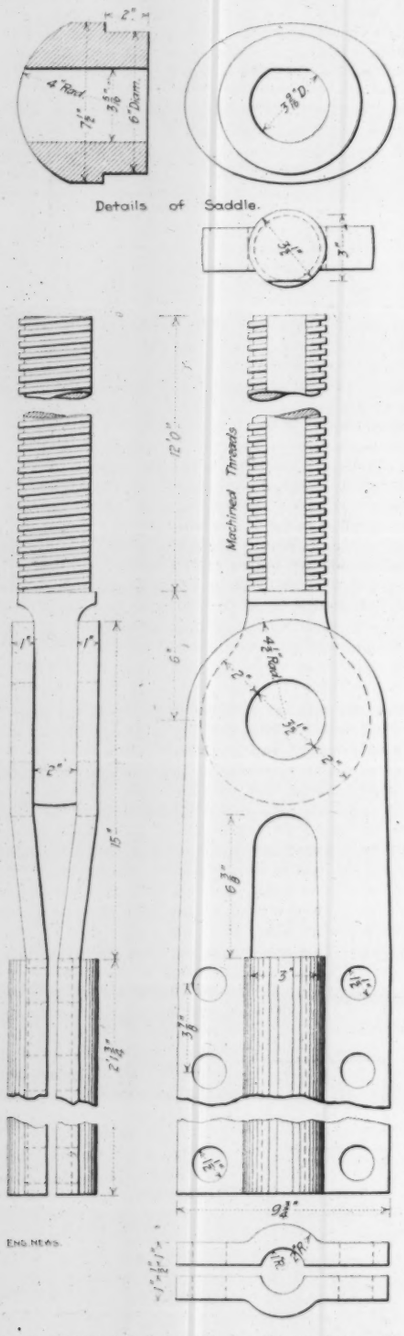

Fig. 6. Details of Cable Clamp, Screw Connection and Saddle on Top of Cap. Proposed Scheme to Raise the "Maine."

that purpose. At any rate, each jack will be manned by at least eight men and, acting simultaneously on signals, these men will lift each cable through a quarter turn of the head nut, a ratchet head being provided to ensure that only a quarter turn can be made at one time. Thus the whole ship may be lifted through the 10-ft. length of the screws and one by one the cables can then be relaxed, the screw dropped and then again taken up and the raising continued.

This possibility of relaxing one screw and cable at a time is one of the main features of the design. It is computed that the cables and their screws are strong enough to bear safely four times the weight of the vessel, so that, if necessary, every other one of the cables could be released at the same time and the vessel could be carried safely on the remaining half. However, it is not intended to leave so many of the cables loose at one time, but the spacing between cables, 4 ft., is quite small enough so that the two next cables, 8 ft. apart, can easily carry the load while the intervening cable is being relaxed and the screw lowered.

Once the vessel has been raised above the water, a platform can be built under her across between the two docks, and held as she is in the cable cradle, the bodies of the men can be removed, the hull examined and repaired and the vessel can be entirely refitted so as to leave Havana under her own steam.

Measurements of Road Resistance of Automobiles.

By H. E. WIMPERIS.*

The method of measuring the road resistance of an automobile by means of the Wimperis accelerometer was explained in Engineering News, April 28, 1910, in connection with a description of the instrument. From the road resistance can be deduced the brake horsepower exerted by the engine at various speeds on the given road. The results of two road resistance tests made by the author are shown in the accompanying curves.

One of the tests was made on a loaded motor wagon (total weight loaded 7,500 lbs.) and the other upon a solidly built touring car (total weight loaded 5,000 lbs.). In each case the wheels were fitted with solid rubber tires. The governor was set to a maximum speed on the level of 15 mi. per hr. in the case of the motor wagon and 22 mi. per hr. in the case of the touring car. An Elliott speedometer was used in each case to determine the speed.

A series of measurements was first made of the "coasting" resistance, at various speeds, with the engine detached, and a further series was made when the engine clutch was left in but with the ignition cut-off. The accelerometer dial was graduated directly in pounds per ton so that no calculations were necessary in interpreting the readings. In every case the tests were taken on a slight declivity so that the speed changed very slowly. This had the advantage of giving steadier readings and made unnecessary any correction for the energy stored in rotating parts.

The results of these measurements are seen in Figs. 1 and 2, where the resistance is shown in pounds per ton (of 2,000 lbs.) for various speeds. It will be seen that the engine friction is very nearly constant for all speeds and may in fact be looked upon as a backpressure steadily exerted on the piston. The resistance rises rapidly with the speed, mainly because the air resistance, being proportional to v^2, becomes increasingly important at the higher speeds. But account must also be taken of a term proportionate to v. The ratio between the ordinates of the two curves seen in each diagram is of course, the mechanical efficiency of the engine and in each case it is about 75%. In Fig. 3 is plotted the brake horsepower deduced from these curves, and it shows clearly the rapid rise in power made necessary by higher speeds.

It will be seen that the points in Fig. 2 do not lie quite as evenly as those in Fig. 1. This is due to the fact that the first test was made on a calm day while the results in Fig. 2 were obtained on a day on which there was a brisk side wind which had a component in the direction of motion of the automobile and therefore slightly altered the air resistance, besides making the readings slightly less steady through the gusts encountered at openings in the hedges, etc. All the tests were made on first-class English main roads when perfectly dry and hard. It would be useful to know how these compare with what would be obtained on various classes of American roads.

Curves of this kind are needed by automobile designers so that they may have other guidance than ingenious "guess-work" in fixing the engine power necessary for any given conditions as to speed, load and road surface. The curves, in fact, occupy a position in this work corresponding with that of the "characteristic curves" of the electrical engineer.

It may be mentioned that during one of these tests some half-rolled road metal had to be crossed and it was found that the resistance ran up at once to over 130 lbs. per ton, with a speed of only 15 mi. per hr. During a part of the same run a hot journal made the resistance increase suddenly by 30 lbs. per ton, but this increase disappeared immediately after the journal had been allowed to cool and had been given a fresh supply of lubricant.

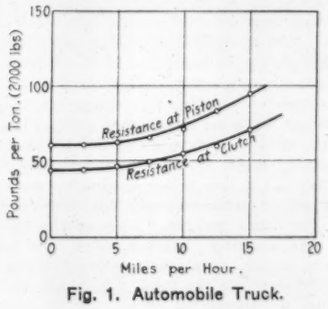

Fig. 1. Automobile Truck.

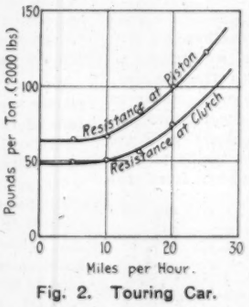

Fig. 2. Touring Car.

FIGS. 1 AND 2. CURVES PLOTTED FROM RESULTS OF TESTS OF AUTOMOBILE ROAD RESISTANCE.
(Road resistance measured with a Wimperis accelerometer.)

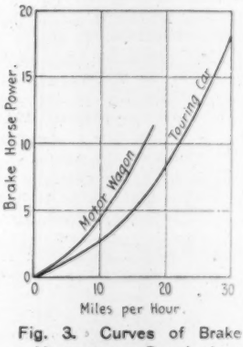

Fig. 3. Curves of Brake Horsepower Required at Various Speeds for the Propulsion of Motor Vehicles on a Macadamized Road in Good Condition.
(Plotted by computation from the results shown in Figs. 1 and 2.)

THE WATER FILTRATION PLANTS OF PHILADELphia will have a total daily capacity of 367,000,000 gals. on the addition of the Queen Lane plant which is now well under way. The number of total units, the area per unit and per plant, and the daily capacity of each plant are as follows:

		Area.		Capacity, million gals.	
	No.	Per unit.	Total.	Daily, filters.	Total, clear water basins.
Lower Roxborough...	5	0.53	2.65	12	3,000,000
Upper Roxborough..	8	0.70	5.60	20	8,000,000
Belmont	18	0.735	13.230	40	16,500,000
Torresdale	65	0.75	48.75	220	50,000,000
Queen Lane.....	22	0.76	16.72	75	50,000,000

Connected with each filter plant is a filtered or clear water basin. The foregoing figures are taken from the official city bulletin called "Philadelphia." The issue for June, 1910, is devoted almost wholly to a description of the water-works of the city. The daily water consumption of Philadelphia is placed at 390,000,000 gals. per day.

*28 Rossetti Garden Mansions, Chelsea, S. W., England.

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Everyone knows that wages have gone up and hours of labor have gone down in marked degree during the last thirty years or so. Just what the changes have been in a considerable number of trades may be seen by consulting some brief tables published in our Current Prices Supplement this week. A notable feature of the figures is the much greater increase in wages and decrease in working hours secured by men in the building trades than in other industries. Bricklayers, carpenters, etc., averaged together, get 135% more pay for every hour worked now than they did in 1878, while the other skilled laborers included in our tabulation receive only 85% more. In 1878, nearly all the trades listed were on substantially the same basis as to hours of labor, but the slight lopping off of an hour or two from the 60-hour week had been secured almost exclusively by employees in the building trades, those in all but one then working 58 or 59 hours instead of 60. In 1910, we hardly need state, 44 hours per week, or an 8 instead of a 10-hour day, and a half-holiday on Saturday instead of an hour or two off, was enjoyed by every building trade, but only two of the other trades in our list had secured so great a concession from their employers. The figures as a whole will scarcely fail to interest anyone who will turn to our Current Prices Supplement for August, which follows directly after the Construction News Supplement.

An interesting development in inland navigable waterways, although one of minor importance, is that through communication available for barge navigation between Lake Michigan and the Mississippi River has been established by the completion of a connection between the Chicago Drainage Canal and the old Illinois & Michigan Canal near Joliet, Ill. The latter canal extends from the Chicago River at Chicago to the Illinois River at LaSalle, and from Chicago it parallels the Drainage Canal to the latter's terminal at Joliet. The portion above Joliet, however, has for many years been in an extremely dilapidated condition and quite impracticable as part of a transportation route. It may now be abandoned, and with it the old pumping station at Bridgeport (Chicago). That portion of the canal below Joliet, however, is in very much better condition. The Drainage Canal and the Illinois River can accommodate lake and river steamers, respectively, but the canal link between them is available only for barges and small boats. By improving the Illinois and Des Plaines rivers, ship navigation might be made practicable from Lake Michigan to the Mississippi, but this is a matter for the future. However, barges 80 ft. long, 16 ft. wide and with a draft of 4 ft. can be operated now between Chicago and Mississippi River ports, and it is stated that such barges can carry 200 tons of freight or cargo on the maximum draft. It is reported also that two transportation companies (one at St. Louis and one at Chicago) have been organized to operate a local service of this character. When such service is in operation it will be of interest to see what patronage it receives and how a Chicago-St. Louis barge line will develop as a practicable freight-carrying route.

In another part of this issue we have reviewed certain reports by Mr. Bion J. Arnold on the troubles of the present transportation facilities in Pittsburg. The street-railway service there seems to have been going from bad to worse until, we should judge, the present conditions could not long be tolerated. There are, for instance, too many cars on some streets and too few on others; there is a congestion of cars near important centers; transfer privileges have been curtailed so that inconvenient routes are forced on passengers; there is a lack of cross-town service; there was a million dollars deficit last year and equipment has been neglected until many cars are not only forbidding in appearance but even getting dangerous to life and limb. Unless some remedy is found it is only to be expected that soon the guaranteed dividends on stock of controlled companies cannot be paid and then the system must break up into the many original parts with a kind of operation most unsatisfactory to the public.

Unfortunately, similar troubles may be found, to a certain extent, in many street-railway systems all over this country. The troubles in these other places may not be so acute as in Pittsburg, but they are certainly educating the public in the economics of exploiting public service and they are arousing more or less effective protest. In Mr. Arnold's reports not even covert dishonesty is implied, and dishonesty does not explain the trouble in the other cases. There may almost be said to exist a disease of American street railways, the seeds of which, like many real diseases, were sown in the excesses of youth. The situation illustrates the folly of some old methods of financing and operating (!) public utilities arising from inadequate and dejecting ideals and promoters and a once under-developed public conscience.

It was not held dishonest to rebuild a public horse-car line into a cable system and to rebuild again for electric traction, with the final capitalization holding, absolutely without liquidation, the full cost of discarded equipment, unproductive labor and inevitable mistakes. Such a procedure may not be held actually dishonest to-day, but it is at least held as reprehensible and perhaps soon it will be prohibited by some force of crystallized public opinion.

It was once perhaps justifiable to place the capitalization of a street-railway, or other public utility, at some dreamed-of value as a profit producer, but there is little excuse for making the public pay everlasting profits on these dreams through generations untold. Promoters must have their reward for risk, it is true, but they must soon seek it openly in larger return on a conservative capitalization; if they feel entitled to 15% on ventured sums, soon they must say so and not hide behind a fictitious 6%. The demand is becoming more and more effective that the annual return on a public-utility business shall be only a fair reward for skill, risk and zeal plus a small interest on the investments actually yielding service, and that the margins between total cost and real value shall be liquidated, as depreciation, out of earnings.

In private business, if anywhere, there may be an excuse for combining several competing concerns, each with artistic capitalization, and for guaranteeing a good return on the stock, but a rising sentiment demands that public services be freed from the effects of such excesses.

The remedies proposed by Mr. Arnold for the Pittsburg symptoms are, of course, the generally accepted principles for removing the causes and for guiding the organization and operation of the system. The remedies are broadly applicable to other cities suffering from similar faults of early development. Cooperation is proposed between the city and the company in rehabilitating the property and in rerouting the lines. Complete publicity of plans and results is advised in providing for depreciation, in securing new capital and in arranging adequate service. An equitable division of benefits and burdens is urged.

So far as we have seen, nothing has been reported about reducing capitalization, but the market may already have done just that in effect, although we do not know at what figure these stocks are quoted. As the present proposals involve the payment of only a fair return on the true values of the properties and as these values amount roughly to half the capitalization, we may expect that the stock quotations have or will drop 50% until the return bears a reasonable ratio to the purchase price. It would materially clear the atmosphere, however, and it would help to impress the public with the sincerity of the officials in assuming and adhering to a broad public policy, if the nominal stock values could be brought closer to the actual; it should eliminate lurking fears of insidious juggling to get a good return on the old capitalization.

An awkward way of collecting an awkward street railway fare is reported from New England. A 6-ct. fare on certain lines having been imposed by the Hartford & Springfield Railway such difficulties were experienced in collections that a "ticket agent" was placed on each car in addition to the conductor. When the conductor began to collect fares at the forward end of the car the "ticket agent" started selling 6-ct. tickets at the rear. After the two met, near the center of the car, the conductor employed his leisure time in collecting the 6-ct. tickets. We are not informed as to what the "ticket agent" does with his leisure or what becomes of the 6-ct. tickets held by passengers near the door who get off before the conductor catches them.

Standardizing the Design of Street Railway Track.

Street-railway track differs essentially from the track construction of steam railways and electric interurban railways in having a great diversity of types instead of one uniform type. On railways of the two latter classes, the universal type of track consists of T-rails, with bolted splice joints, the rails spiked to closely-spaced wooden ties laid in a bed of ballast. The few variations from this construction, such as the use of steel or concrete ties instead of wooden ties, or screw spikes instead of drive spikes, are so limited as not to affect the statement as to the typical or universal character of this construction.

In street-railway track, however, no such uniformity exists, and practically every railway of this class has its own type of construction. Not only does this lack of uniformity apply to the various lines, but as a matter of fact any street-railway system of moderate size which has been in existence for (let us say) ten years, has usually a number of different types of con-

struction upon its lines. Some of these varieties are designed as improvements upon earlier types, while others are due to the varying opinion of different engineers employed by the company at different times. The main reason for this condition is that each street-railway system is a unit in itself, and there is at first sight no apparent reason why an engineer should not introduce (whether in construction, renewals, or extensions) the type of track which to him seems the best, either as an entirely new type or a modification of earlier types. In the design of the track, the engineer is influenced to some extent by other designs, but more especially by considerations of cost, of traffic, and of the type of paving to be used (which last may be decided for him by municipal requirements). The unit or independent character of street railways is indicated strikingly by the multiplicity of widths of gage now in use. There are in fact nearly a dozen gages of track, many of them used on lines aggregating a considerable mileage. They range from 3 ft. to 5 ft. 4½ ins., and several of them differ only slightly.

It is obvious that street-railway systems must remain always as units, each subject to local conditions and local municipal requirements. At the same time it is quite possible that a number of such units may come under the ownership or management of one company, in which case there would be greater incentive toward the adoption of some uniform design of track construction. This condition exists already in several cases, and tends to increase (as far as the smaller units are concerned) by the development of interurban railways which build or acquire street railway systems in towns along their lines.

It is worth while considering, therefore, the question of the possibility of standardizing the track construction of street railways. Some suggestions upon this line were given in a paper read before the Street Railway Association of the State of New York by Mr. B. E. Tilton, of Rochester. The ideas presented will no doubt attract considerable attention in street-railway circles, and an abstract of this paper is given elsewhere in this issue. The following fundamental questions suggests themselves: (1) is it practicable to standardize the design of street-railway track? (2) if it is practicable, what would be the advantages?

In the first place, let us see what constitute the present types of construction. The foundation may be of ballast or concrete, or of both in a variety of combinations, while the concrete may be arranged in various ways, as noted later. Both wood and steel ties are used, with close, medium or wide spacing; metal tie-plates are used extensively to protect the ties and support the rails. The rails are of innumerable sections, with joints of various kinds, and sometimes secured not only by being fastened to the ties but also by being anchored to the concrete. Tie-bars connecting the rails are used in many cases, and all these numerous parts are used in great variety of form and of combination.

With ordinary railway track construction on the open line there is continual wear or disintegration of every part (including the ballast), which necessitates continual inspection and periodical repair or renewal. For maintenance, also, the track must be considered as one structure, and not as a number of independent parts. Thus, tie renewals involve dressing and tamping of the ballast, and rail renewals cannot be made economically upon decayed ties in poor ballast. With street-railway track, however, the conditions are somewhat different, and the track structure may be considered as composed of two separate parts. Thus, with a concrete base we may have a permanent substructure (of ties and concrete) to carry a renewable superstructure (of rails and fastenings). Even if ballast is used instead of concrete, the substructure may be considered as semi-permanent, since the ballast is confined in a trench and covered by the paving, so that it is not subjected to disturbance by traffic (after the initial settlement) or by atmospheric influences, as in the case of ballast exposed on an open roadbed. This principle of dividing the track into two parts, one permanent (or practically so) and the other renewable, has been followed in the design of the new standard track construction of Chicago, which design was worked out by a board of engineers representing both the city and the companies.

In the design of the concrete foundation there is great variety. It may be of uniform thickness across the width of the track, or its thickness may be increased longitudinally under each rail (as a stringer) or transversely under each tie. There may seem at first to be little advantage in attempting to standardize the design of the foundation, since the material can readily be laid in any desired form. On further consideration, however, it appears desirable to eliminate transverse trenches and to limit the designs to two general types: (1) a concrete base of uniform thickness across the track, and (2) a concrete stringer under each rail, either combined with or independent of a concrete base for the paving. In a number of designs having a monolithic concrete base, the depth of this base is increased under each rail and tie, but this has been found open to objection in some cases. One objection is that the subgrade or roadbed cannot be rolled; another is that workmen walking over the roadbed break down the edges of the transverse trenches so that the depth of the concrete is not uniform and part of the concrete is laid on loose earth instead of on a compacted surface.

A somewhat doubtful feature of some designs is that the foundation concrete is carried up over the rail base. In rail renewals, this part of the concrete must be broken away, and probably the new concrete filled over the new rails will not make an effective bond with the main mass of concrete. The purpose of this arrangement is to use a deep rail and at the same time bring the top of the concrete to a proper level for the paving. While it may be of advantage in helping to hold the rails in line, it has the disadvantage of departing from the principle of keeping the substructure and superstructure separate. It may have been considered that as the design necessitated carrying the concrete above the level of the rail base (to avoid a deep sand cushion for the paving) it would be well to utilize it to hold the first rails at any rate. This instance indicates the influence which the paving design has upon the track design.

In regard to the substructure, a difficulty which possibly might arise is in the laying of new rails of greater height than those used originally, as in the case of strengthening a track to carry heavier cars. This might perhaps involve the tearing up of the substructure in order to lower its level, unless arrangements could be made for adjusting the pavement to the new rail. With concrete and wood ties it might be practicable to cut a groove or channel for the new rails, but this would not be practicable with steel ties in concrete. The occurrence of such a problem, however, would be very improbable on a well-built track.

Wood ties have a long life when embedded in concrete, especially if treated by some preservative process so as to resist decay, and there is an increasing use of such treated ties in order to obtain greater permanence of the substructure. They should be protected also against mechanical wear (both of the rails and spikes) by metal tie-plates and improved rail fastenings. Steel ties may be considered as practically indestructible in the concrete base of street railway track, and may have fastenings which will permit of adjustment to rails of different sizes. Steel tie-plates are used with both wooden and steel ties on the reconstructed tracks in Chicago, for the purpose of protecting the substructure and isolating it from the renewable superstructure. Concrete ties have been used but little, if at all, in track of this kind; they appear to be adaptable to it, however, especially as they would be free from the severe shocks which have proved destructive to many such ties in steam railway track by causing disintegration of the concrete.

In view of the great extent to which the concrete foundation is used, it appears strange that the use of closely-spaced wood ties continues to be so general, especially as there has been sufficient experience in this country and abroad to demonstrate the practicability of laying rails directly upon concrete. It is true that in some designs the ties are given a spacing of 5 ft. or more, the rails being secured to the concrete base at intermediate points. These latter attachments may be anchor bolts (with bottom plates and top tie-plates), or stirrups embedded in the concrete; or the rails may be secured to cast-iron chairs which form a support as well as an anchor attachment.

The rails need to be held to the ties or concrete at a sufficient number of points to keep them in position and to prevent any waving of the surface. With deep rails, however, there is comparatively little trouble in maintaining proper surface. There is greater difficulty in maintaining the rails in line, and deep rails especially may be deficient in lateral stiffness. For this reason, where such rails are used, it is common practice to connect them by means of tie-bars passing through the webs, or to support each rail on the outside by a combined rail-base and tie-plate. The tie-bars have the advantage of holding the two rails together, but a disadvantage is that in block paving they necessitate wide joints in the pavement, and these joints soon become visible.

None of the features thus far considered appear to offer much field for standardization, but we come now to the question of rails and standard rail sections, which opens up a more definite and promising line of investigation.

The standardizing of rail sections for street railways would be of advantage to the mills in enabling them to roll for stock, as in the case of rails for steam railways. It would be an advantage also to the railways in giving better facilities for prompt supply (and probably better prices) than where rails of a special section are required, particularly if the railway places only a small order for renewals. The arguments which applied in earlier discussions on the standardizing of railway T-rail sections apply to a large extent in this case, and the many advantages resulting in the adoption of standard sections for T-rails promise equal advantages following the adoption of standard sections for street rails. Some steps in this direction have been taken already by the American Street and Interurban Railway Association, but there is a vast amount of work yet to be done in designing standard sections and in securing the general adoption and use of these standards.

The matter is complicated to some extent by the fact that different types of sections are required for street railway track, while for steam railways all the old sections were simply modifications in form of the T-rail. The old stemless T-rail and box-girder or saddle rail supported on cast-iron chairs, which were used in various designs of street track, are not obselete (in this country at least), but at the present time there are four distinct types of rail sections used for street railways: (1) the ordinary T-rail as used in steam and interurban electric railway track (and usually of the Am. Soc. C. E. section); (2) the T-girder rail, which is considerably higher than the ordinary rail in order to adapt it to paving requirements; (3) the tram-head or step-head rail; (4) the grooved-head rail. Rails of the third and fourth sections are now usually deep or girder rails. Three of these types are perhaps necessary in order to meet different conditions. But it might be possible to eliminate the step-head rail, as this section possesses the objection of necessitating an undesirable form of surface for the paving (lower between the rails than on the outside). At any rate its use should be reduced to a minimum and confined to streets of light traffic.

The T-rail has been reduced to standard sections for some years past, and a large majority of the rails rolled are of the sections recommended by the American Society of Civil Engineers. These rails are commonly used for the track of interurban railways. In fact, the so-called "Am. Soc. C. E." rail sections are as much

standard commercial sections as the sections of I-beams and rolled shapes. It is true that a few large steam-railway systems still use special sections of their own, but the use of each of these is confined as a rule to the individual system, and the sections are not in general use.

The street railway rails of the other three types mentioned are made in innumerable sections, varying not only in height and weight but in all the details of shape and dimensions. There seems to be no good reason why the number of these sections, many of which are practicaly identical, should not be reduced very considerably, with advantage to the manufacturers and the railways.

There is, however, one very important factor affecting this matter of standard design of rail sections, and applying particularly to the depth of the head and the depth and form of the groove. That factor is the wheel flange, the depth and form of which varies considerably. Some steps have been taken toward standardizing the wheels, but there are conditions to be considered which did not enter into consideration in the earlier standardizing of railway car wheels. One of these is the desirability of keeping the flange section at a minimum in order to avoid an unduly deep and wide groove in the rail or paving, which would be specially undesirable at complicated crossings or special work.

Another condition is the use of cars of different types. On the one hand is the light street car for local service and moderate speeds, and sometimes mounted on four wheels only; on the other hand, is the heavy high-speed interurban car, whose wheels must have flanges of ample size for strength and for holding the car to the rail. In many cases, cars of the latter class run over street tracks operated by the lighter "street cars," and the large wheel flanges may cause considerable wear or displacement of track having grooves or flangeway of limited dimensions. The outside edge of the wide tread of the interurban wheels also may crush or displace the paving along a narrow-headed street rail, particularly if the wheel is worn hollow in the tread. With the introduction of the large cars now common in many cities, wheels practically the same as interurban wheels are coming into use for cars which are distinctively "street-cars." But the fact remains that the standardizing of rail sections cannot be carried to its full extent until wheels have been standardized to a greater extent than at present.

In the form of the groove, the rails present two distinct types; there is, first, the narrow groove, with practically vertical sides, giving a minimum break in the street surface but having the objection of causing dirt to collect and clog; the dirt tends not only to impede the progress of the car but also to interfere with the clean contact of rail and wheel for the passage of the return current. In the second place, there is the wide and self-clearing groove, having the guard side flaring outward so that the dirt may be forced aside instead of being packed under the wheel flange. In either of these cases the rails may have wide or narrow heads, and a great variety of form in matters of detail.

The design of a rail joint for street-railway track involves some special considerations, one of which is the necessity of permanence and the reduction of maintenance work to a minimum. Loose bolts and low joints are undesirable anywhere, but on ordinary open track the bolts can be inspected and tightened easily, and low joints can be raised without much trouble. In a paved street, however, inspection and repair of any kind necessitates the tearing up of pavement and more or less interference with traffic. The stiffness of deep girder rails tends to reduce the joint troubles, and with such rails double rows of bolts are commonly used. In many designs, also, some form of base support is used, either independent of or integral with the splice bars, and such reinforcement is especially desirable with shallow rails. Welded joints are extensively used (either welding the rail ends together or welding splice bars to the rails), and riveted joints are used in some special designs.

There is great diversity in the design of rail joints, and it does not seem likely that this condition will be changed. But as nearly every railway has a variety of these joints, it should be practicable in many cases for the engineer to gradually reduce the number and so facilitate the purchase of material and the work of maintenance.

The switch construction is entirely from that employed on open track, since no wide and deep opening for the switch rail is permissible. As a rule there is but one movable switch point or tongue. This is on the outer side, and a fixed point or mate is placed on the opposite (inner) side. The switch point is a flat bar of tapering form, hinged at the heel and supported for its entire length by the grooved base or casting in which it moves.

For switches, frogs and special work, where the traffic is heavy it is now general practice to use hard steel in some form. In some cases the entire work is built of such steel, while in other cases the parts subject to most wear have hard-steel inserts (renewable or otherwise). The former practice, of course, is very costly, but is often adopted for work in busy city streets with a view to greater permanence, but as the greater part of the high-grade steel serves merely to support the part which receives the actual wear, a construction of equal strength but lower cost is very desirable and should be practicable The standardization in this case would be for each railway to adopt one particular type of construction, and to reduce the designs to as small a number as possible. While in cities there will be places calling for special design, such as at complicated junctions or intersections, .there should be little difficulty in preparing standard plans for ordinary work of this kind.

In summarizing the conditions as to the standardizing of street railway track design as a whole, it may be said that the adoption of any one universal type (or a few types) of construction appears to be quite out of the question. Nor would such a step present any particular advantages, in view of the fact that each street railway system is an independent unit. There are possibilities of improvement, however, in three directions, and careful investigation on these lines should produce some very practical and economical results. In the first place, a reduction in the number of types may be obtained by a study of the distinctive features, with a view to the elimination of defective features or minor points of difference. In the second place, any one street railway company (or company controlling a number of street railway systems) will probably find it of advantage to study the different systems of construction on its lines, with a view to the adoption of standard designs. This might result in a decided economy in the purchase of track material and supplies. In most cases at least two designs will be economically desirable, one for business streets or lines carrying heavy interurban cars, and the other for lines in residence districts with light traffic. But even so, the two designs may be made similar in many respects, or of the same general type, so as to employ similar material.

In the third place, there is the standardizing of individual manufactured parts, more especially in regard to rails and the adoption of a limited number of rail sections. This is perhaps the most important line of improvement as affecting street railway track construction.

The first and second lines of standardization mentioned above can be taken up by each railway system for itself, but the best results, of course, will be obtained by a mutual and concerted action. The third line of investigation, that of standardizing rail sections, can be attacked only by the cooperation of the railways among themselves and with the manufacturers. It seems to us that these lines of investigation and improvement open up a wide field of useful activity for the American Street and Interurban Railway Association, which is now a powerful organization really representative of the street railway interests in all their branches.

LETTERS TO THE EDITOR.

How to Insulate a Concrete Ceiling Slab Against Condensation.

Sir: We have a concrete roof over our boiler-house and in cold weather there is a continual sweat from this roof caused undoubtedly by the condensation of steam and water vapor when it comes in contact with the cold surface. The roof is 4 ins. of reinforced concrete supported by 9-in. purlins on four girders. The size of the girders will not permit the placing of additional concrete on account of weight. There are now five 2-ft. vents in the roof to carry off the hot gases, steam, etc., but they do little or no good. The tops of the windows in the building are from 12 to 15 ft. below the ceiling.

How can this sweating be prevented? If an insulator were placed under the ceiling would there be any advantage gained in leaving an air space of several inches between the insulator and the ceiling? What other method would you suggest? A. S. M.

Middletown, N. Y., July 18, 1910.

Laying Concrete Under Water.

Sir: I beg to question what to me appears to be a too sweeping conclusion in the editorial note in your issue of July 21, p. 78, in which you comment on the failure of the concrete piers of the ocean pier at Long Beach, Cal.

It appears to me that it is a misnomer to term as "piles" these piers or pillars, 4 ft. in diameter and founded on timber piles. A pile was originally a pointed stake or arrow; however, the name or diameter of the structure is not the matter at issue. A pier 4 ft. in diameter is as much a pier as one 10 x 30 ft. or larger, and good concrete can be deposited in the one as well as in the other. The wooden or other casing can be inspected, and there is no reason for there being any holes to allow the water currents to affect the plastic concrete if reasonable specifications are followed. An untold number of piers have been constructed of concrete, deposited under water and have not failed. Some have failed no doubt but not because the concrete was laid under water but because the concrete was not good enough or there was mismanagement either in the plan or execution. Concrete seawalls, though constructed in the dry, have in numerous cases failed, but you would not condemn the use of all concrete for that purpose because some one has made a mistake, before all the difficulties of such work were understood.

Prof. Waterbury makes no statement as to the cause of the failure, other than saying that "the concrete does not appear to have been very good." If it was not good enough when first put in place the ocean pier was doomed from the first, whether placed in a proper casing under water or in the like casing that had been dewatered,

What I claim is that perfect concrete work can be executed under water if proper methods are employed. These methods are open for inspection. Our eyes are not our only senses. I admit that with improper methods good concrete can be spoiled more easily when deposited under water than in the open, but financial reasons often compel its use under water and it does not seem to me good engineering to condemn concrete pile or pier work deposited under water even with a faint-hearted saving clause. Yours truly,

J. S. Armstrong.

Rothesay, N. B., July 22, 1910.

[In the editorial note referred to by our correspondent, the specific criticism was directed not at all against the general practice of laying concrete under water but against the deposition of concrete under water in forms of restricted size and of doubtful tightness. That there is considerable hesitation in depositing concrete under water when any other method is available is evident by the widespread use of cofferdams and caissons, but a great number of admirable structures testify to the success of under-water concrete laying when the operation is carefully conducted, so that no one can successfully condemn such practice. On the other hand, the use of restricted, loose forms in which to deposit concrete under water has not produced very praiseworthy results, and, unless other methods of construction are out of the question, can hardly be recommended.—Ed.]

Notes and Queries.

The process of consolidating or "tamping" concrete by vibration, which was noted in our issue of July 21, has been employed in the manufacture of experimental concrete ties for an English railway, as described in an issue of Feb. 17. It has also been used in this country in the manufacture of concrete fence posts.

The New Irrigation Board of Engineer Officers of the Army in Connection with Certain U. S. Reclamation Service Projects.

We present herewith a group photograph and a chronological summary of the records of the members of the board of engineer officers of the army, recently appointed by President Taft to examine and report on certain irrigation projects.

It may be explained that numerous important irrigation works have been built, or are now under construction, in the western part of the United States under a Congressional Act passed in 1902. This Act set aside the proceeds from public land sales in various Western states for the purpose of constructing irrigation works. In accordance with the Act, the Reclamation Service was organized under the Department of the Interior. Originally the Director of the Geological Survey was at the head of the Service, with Mr. F. H. Newell, M. Am. Soc. C. E., as chief engineer in direct charge of the work. Later on, the work was disassociated from the work of the Geological Survey, and Mr. Newell was made Director of the Reclamation Service, and Mr. Arthur P. Davis, M. Am. Soc. C. E., became chief engineer.

As speedily as possible after the creation of the Service, studies were made to determine the most feasible projects, and at an early date a number were put under construction. Others have been entered upon since. Some of the projects have been completed to the extent, at least, of beginning to supply water on a considerable scale. Others are in various stages of completion.

For reasons which need not be gone into here, there has been much pressure of late for carrying on the work faster than the funds, as originally provided, permit. As a result, a bill was introduced in Congress last winter providing for what was virtually a bond issue, although under the name of "advances to the reclamation fund," the money to be secured, if necessary, by the issue of certificates of indebtedness. The original proposition was to make the bond issue $30,000,000, but the bill as passed carried only $20,000,000.

The expenditure of money realized in the way just indicated is conditional upon: (1) recommendation of the Secretary of the Interior; (2) examination and report on each project to be benefited "by a board of engineer officers of the army, designated by the President of the United States;" (3) approval by the President himself of the project "as feasible and practicable and worthy of such expenditure." The Act specifically restricts the use of any part of the $20,000,000 to the completion of "projects heretofore begun," and also specifically prohibits expenditure "upon any new project."

In accordance with the Act just outlined President Taft appointed, on June 25, 1910, the following members of the board: Lieut.-Col. John Biddle, Lieut.-Col. C. W. Langfitt, and Majors William W. Harts, C. W. Kutz, and Harry Burgess. The records of these army officers, beginning with graduation from West Point and continuing up to their present assignments, are as follows:

MEMBERS OF THE BOARD OF ENGINEER OFFICERS OF THE ARMY APPOINTED BY PRESIDENT TAFT TO EXAMINE AND REPORT ON IRRIGATION PROJECTS SUBJECT TO RECENT $20,000,000 APPROPRIATION OF ADVANCES TO THE RECLAMATION FUND.

(Standing) Maj. Harry Burgess, Maj. Wm. H. Harts, Maj. Chas. W. Kutz.
(Seated) Lieut.-Col. John Biddle, Lieut.-Col. Wm. C. Langfitt.

LIEUT.-COL. JOHN BIDDLE.

(726 Chronicle Building, San Francisco, Cal.)

1881.—Graduated at West Point.
1884 to 1887.—Surveys in Dakota and Montana.
1887 to 1891.—Instructor in engineering.
1891 to 1898.—In charge of lock and dam construction and open channel work on Tennessee and Cumberland rivers.
1899 to 1901.—In charge of road construction and of Manila Harbor development, Philippine Islands.
1901 to 1907.—In charge of construction of Connecticut Ave., Anacostia and other bridges and of buildings, roads, etc., in the District of Columbia.
1907 to 1910.—In charge of Sacramento and San Joaquin rivers, including flood control and of minor rivers; of San Francisco and Humboldt harbors, California, and supervising engineer of all river and harbor work on the Pacific Coast and in the Hawaiian Islands.

LIEUT.-COL. C. W. LANGFITT.

(Washington, D. C.)

1883.—Graduated from West Point.
1883 to 1886.—Student Engineer-School of Application, Willets Point, N. Y.
1886 to 1888.—Engineer-Officer Department of Columbia. Land survey, water supply and sewerage system for post.
1888 to 1893.—River and harbor work, Galveston District.
1893 to 1895.—River improvement, Cincinnati District. Included work on the movable dams of the Ohio River.
1895 to 1898.—Instructor, Engineer-School of Application at Willets Point, New York—one year with troops during Spanish-American war.
1899 to 1905.—In charge of Portland District river and harbor and fortification work. Four years of this time in charge of both river and districts. Also engineer of the 13th light-house District, during which time new lighthouses and fog signal stations were constructed, most of them in the west.
1905 to 1906.—Instructor civil engineering United States Engineer School, Washington Barracks.
1906 to 1907.—In Cuba with the Army of Cuban Pacification, Chief Engineer.
1907 to 1910.—Commandant, Engineer School, Washington Barracks.
Member Board of Engineers Rivers and Harbors from 1906 to 1910, except for one year when in Cuba.
1910.—In charge of the Washington Aqueduct and water-supply of the City of Washington, river, harbor and fortification work, Washington District.

MAJ. WILLIAM WRIGHT HARTS.

(Nashville, Tenn.)

1889.—Graduated at West Point; transferred to the Engineer-School of Application at Willetts Point, N. Y., for a post-graduate course in civil and military engineering, including hydraulics, water-works and sewerage.
1892.—Newport, R. I., as assistant. Constructed torpedo casemates at Fort Adams and Dutch Island in Narragansett Bay, and was engaged from time to time on the construction of the Point Judith Breakwater.
1895.—At Cincinnati as assistant in local charge of construction and operation of the locks and dams on the Kentucky River.
At the breaking out of the Spanish war was attached to the battalion of engineers for duty in Cuba and was later detached and sent to St. Augustine for duty in placing submarine mines. Placed the system of mines in the St. Johns River near the mouth and made preparations for a similar system for the approaches to Tampa.
1898.—Portland, Ore. Completed the North Jetty at Coos Bay; also portions of Cascade Locks in the Columbia River.
1901.—In Philippine Islands. In charge of roads and bridge work in the Island of Luzon. Surveyed, designed and laid out work for construction of Fort William McKinley near Manila.
1903.—At San Francisco as executive disbursing officer of the California Debris Commission and as Chief Engineer in Charge of the Division of the Pacific. Carried on work on the project for restraining debris on the Yuba River and prepared new project for debris control by dredging.
1907.—At Nashville, Tenn., in charge of work on the improvement of the Cumberland and Tennessee rivers.

MAJ. C. W. KUTZ.

(Seattle, Wash.)

1893.—Graduated at West Point.
1893 to 1896.—Post-graduate Engineer School.
1896 to 1901.—Assistant on River and Harbor, and Fortification Work, Ft. Monroe, Baltimore and Portland, Me.
1901 to 1903.—Commanding Engineer Company.
1903 to 1906.—Assistant to Chief of Engineers.
1905 to 1906.—Member of Board of Engineers for Rivers and Harbors.
1906.—Investigated power development and water diversion at Niagara Falls.
1906 to 1908.—Instructor of Practical Military Engineering and in charge of water-supply, U. S. Military Academy.
1908 to date.—In charge of Seattle, Washington, Engineering District, involving River and Harbor, fortification and road work.

MAJ. HARRY BURGESS.

(New Orleans, La.)

1895.—Graduated from West Point.
1895 to 1898.—Under instruction at Engineer School and at River and Harbors and Fortification works.
1898.—Spanish war, submarine mine duty.
1898 to 1900.—Instructor in Engineering, U. S. M. A.
1900 to 1901.—Military roads and bridges, Philippine Islands.
1902 to 1903.—Military duty in Kansas.
1903 to 1908.—In charge of river improvement works in Louisville, Ky.
1908 to 1910.—In charge of Fourth District Improvement, Mississippi River, New Orleans, La.

The board is now in the West, visiting the irrigation projects in question.

For the sake of completing the information regarding the conditions surrounding this $20,000,000 advance or loan, we may state that the certificates are to be redeemable at any time after three years from date of issue and are to be payable five years thereafter. The Act, however, does not seem to compel payment at the end of five years, for one of its sections provides that, beginning five years after the date of the first advance, 50% of the ordinary annual receipts of the reclamation fund will be paid into the U. S. Treasury and that payments will continue at the same rate until they amount to the principal and interest up to the time of final redemption, including also expenses incident to preparing, advertising, and issuing the certificates.

All expenditures from the $20,000,000 fund are to be charged up to the several projects between which they are appointed, and be included in "future estimates of construction, operation, or maintenance."

Pittsburg's Transit Problems: Reports by Bion J. Arnold.

Present Troubles.

The transit service and facilities of the Pittsburg Railways Co. have received much severe criticism in the past three or four years. The service has been irregular and infrequent and the cars have been forbidding in appearance until the company has lost the good will of the patrons. Mr. Bion J. Arnold, of Chicago, who was employed by the Pittsburg Civic Commission and by the mayor of the city to investigate its transit problems, in a report dated July 19, discusses the underlying causes. As these are typical of other street railway systems under criticism they are reviewed here.

The first of the root troubles stated is the excessive actual cost of the property through rebuilding them from horse to cable traction and finally as electric lines, but always capitalizing the cost of change. After this are the non-paying extensions made in an effort to prevent competition. The whole system is characterized as "over-expanded."

Third in the list is seen the item of over-capitalization. This is held to have arisen during the consolidation of the separate companies by guaranteeing dividends on the old stocks, which were part water. The companies are said to have been absorbed with good profit to the former owners and in floating bonds the interest rates have been high and the discounts liberal. It is reported that a new system of 550 miles of track could be produced for about $55,000,000, and that this would give better service than the present system, of 581 miles trackage, and costing some $110,000,000.

There was a deficit for the year ending March 31, 1910, of $1,321,453, the net earnings, above operating expenses and extra ordinary repairs, were not enough to meet the "fixed charges" of $4,584,616 (rentals of leased property, $2,278,-89; interest on funded debts, $1,869,990; miscellaneous interests and discounts, $435,757).

Fourth in the list of root troubles is the lack of adequate depreciation and renewal provisions. During the eight years of operation under the present management only $1,000,000 has been put back from earnings into the property to take care of renewals, while the deteriorations of the property due to ordinary wear and tear has been at the rate of about $1,000,000 per year. It is true that several millions have actually been spent on renewals, but this money has been raised for and charged to the capital account. The fixed charges were so high that there were not sufficient net earnings, after paying operating bills, to care for the renewals.

Another contributing trouble has been the unforseen loss of traffic incident to periods of business depression. To meet the curtailment of revenue, the service was reduced in quantity and quality, but this had only a further effect in discouraging travel.

Finally, the routing of the cars is inconsistent—the result of haphazard growth rather than of design. More cars are run on some main streets than are needed while at other places there is a lack. Looping, in the downtown district, has led to congestion; attempts to operate "direct" cars and curtailing transfers has caused confusion. There is a need of thorough routes across the business district, to carry the profitable short-haul traffic. The existence of old routing agreements between companies, the franchise requirements for outlying districts, the lack of turning facilities at the end of some lines and the impossibility of running modern double-truck cars in narrow streets, each and all contribute to the present embarrassment.

Immediate Needs.

The longer the present situation is left to drift, of course, the greater will become the burden on the city. The usefulness of the railway system will decrease, if the cumulative results of the defects noted are not checked, until the system breaks up its original components, an action to be followed with poor and inadequate service, tedious litigation, a reduction of values and an eventual reorganization along lines which are now open.

Mr. Arnold states that the present problem is to get the city and the company together

to develop and disclose a consistent, comprehensive and continuous program which, when carried out, will (1) rehabilitate the physical property, (2) secure new capital for improvements, (3) provide for depreciation, (4) re-route the entire system, (5) provide adequate service.

Mr. Arnold urges cooperation in the planning, building and operation of the system, publicity of plans and results, and a fair division of the burdens and benefits.

The Re-Routing Problem.

In a supplementary report Mr. Arnold discusses how, when and where to run the Pittsburg cars. The problem is of such far reaching importance that he recommends resort to official conference between city and company officials. The fundamental principles of routing applicable there are to be studied and such an equitable balance between the various interests served as will remain in balance is to be sought.

To improve the routing of cars five steps are proposed. These are stated by Mr. Arnold as follows:

(1) Determine the relation that should exist between income and service by agreeing that a certain percentage of the gross earnings from operation shall be used in giving service; the balance to be retained by the company for fixed charges and profits.

(2) Study the requirements of each section of the city and district and the physical difficulties to be contended with.

(3) Establish the principles of routing that will result in the most economical distribution of the car miles available with a given income.

(4) Provide a system for the recording and the checking of schedules, delays and accidents. These records should be constantly used for improving the service and should be public.

(5) Make provision for extending and altering the tracks and routes to take care of constantly growing and shifting demands.

It will be decidedly ineffective work to approach the rerouting part of the transportation problem without an equipment for securing the information needed as well as a definite understanding that a comprehensive plan is to be developed, which will be acceptable to and accepted by the majority of interests affected.

Certain facts have to be collected as the basis of the studies recommended, and the following records are given by Mr. Arnold as necessary:

(1) MONTHLY RECORDS of the number of passengers, number of car miles and earnings per car mile on each route for several past years.

(2) CONTINUOUS DAILY RECORDS showing the earnings of each car on each route, the total number of passengers carried by each car and the actual time of each trip as compared to the scheduled time.

(3) THE PHYSICAL LIMITATIONS of each route showing length of line, curves, width of streets, obstructions at corners, distance between tracks, overhead obstructions, grades, terminal facilities and connections with other routes.

(4) THE PRESENT SCHEDULE showing the number of cars scheduled at different times of the day for summer and winter service, and the time required for each run during rush hours and non-rush hours.

(5) THE LOCATION OF CAR HOUSES AND STORAGE TRACKS and a statement of the dead mileage which the present arrangement entails in running empty cars to and from the ends of their routes when placed in or taken out of service.

(6) RECORDS OF COUNTS on passengers and seats which have been made from time to time by the city and by the company at various checking stations.

(7) RECORDS OF INDIVIDUAL CAR TRIPS which have been made and which ought to be made to ascertain when the passengers board the car, how far they travel and when they alight, and the ratio between the maximum number of passengers using the car on a given one-way trip and the maximum number on the car at any one time.

(8) A STUDY OF TRANSFERS showing the total number and the character and size of the transfer load at transfer points.

(9) RECORD OF FRANCHISE REQUIREMENTS and agreements between underlying companies which affect the number and location of the cars on the various lines.

(10) COPIES OF WORKING AGREEMENTS with operating men as to hours of work, tripper or swing back runs, etc.

(11) FULL LIST OF CAR EQUIPMENT, available, ordered and contemplated, with data as to possible changes which will allow for double-ended operation.

A tentative statement has been made by Mr. Arnold of nine fundamental guiding principles of routing. This is generally applicable, though specifically applying to Pittsburg, and will be read with interest by all who have to deal with the public in satisfying demands for adequate service.

PRINCIPLES OF ROUTING.—(1) Measure of service on any route should take into account the ratio between the total number of passengers in the car for the entire one-way trip and the maximum number on the car at any one time. This "loading factor" is different for different routes, and if the continuous records for individual car loading is to be an indication of the relative demands for seats, this factor should be determined for each route and used intelligently.

(2) To determine whether any part of the system should be on a through line or on a transfer route, the demand for seats during the rush hour on that line should be sufficient to call for, say, six large cars per hour; otherwise it will probably be found that better service may be supplied by a small car operating more frequently in a shuttle service.

(3) There may be routes or lines upon which shuttle service might be provided to the best advantage at all times except during rush hours, when "through" cars can be provided.

(4) Transfers are not a hardship if the passengers get something in return to compensate them for the inconvenience of transfer—for instance more frequent service in large comfortable cross-seat cars for at least part of the ride.

(5) The small single-truck cars should be operated on the hills, and on cross-town transfer lines, but should be kept out of the terminal district and off the main thoroughfares.

(6) In the down-town district, the long-haul routes should make use of the short loops and the short-haul routes should use the long loops, as the long-haul passengers will walk further to get a seat than the short-haul passengers.

(7) Through routing can be established gradually, by first connecting the short-haul routes on different sides of the city in such a way as to form through routes, and as these first routes prove successful, more thorough routes may be added.

(8) Transfers should be given in an effort to cut out useless car miles and by concentrating traffic on through routes secure the efficiency that comes with the most efficient traffic density.

(9) If it can be agreed that the service to be supplied is measured by the income, then the "one city, one fare" principle and a very liberal transfer policy can be adopted, and there will be no question as to whether or not the patrons of the system will get back in service their share of the fare.

The working out of the whole problem of routing, therefore, starts with determining definitely how much of the income is available for service, then how many car miles this appropriation will supply, and finally what disposition of this service will best supply the demands for seats.

This program presupposes that the records of the present routing and service will be available, that the results of a complete system of checking future operations will be made public and that there will be a continuous and effective cooperation between the company and the city in considering and carrying out proposed changes and eventual improvements.

A Pittsburg Subway.

In a preliminary report dated June 29, 1910, and addressed to the Mayor of Pittsburg, Hon. W. A. Magee, Mr. Arnold answers several questions about the possibilities of rapid transit there. This report dismisses the elevated road, with a word about its great local handicap, to discuss at some length the advantages of a subway, its feasibility and financing. He states that it will admirably overcome the natural divisions (hills, ravines and rivers) between the several communities of the Pittsburg District, and that it will eventually become a civic necessity. The questions he considers are (1) where, (2) how soon and (3) under what financial restrictions should subways be built there.

Answers to the first two questions are developed together. It is estimated that the first cost of a double-track subway would be between $1,000,000 and $2,000,000, depending upon the design and the difficulties encountered, and that a subway becomes feasible in Pittsburg only when an expenditure of at least $30,000,000 can be contemplated, half of this to be for the first line.

The operating expenses of a subway system are reported to have been found to be 50% of the gross earnings, as a fair average—compared with 60 to 70% for a surface system. In addition, the speeds are greater and the cars are larger, so that the subway has several advantages where there will be enough traffic over the expensive structure to reduce the fixed charges to a reasonable sum per car mile.

Annual earnings, according to Mr. Arnold, have been found to be usually between 10 and 15% per year, of the first cost, and to assure a practical system in Pittsburg 12% is considered necessary. Therefore the first section of any future subway there must earn $1,800,000 per year (12% of $15,000,000). The per capita earnings of the Pittsburg surface lines average $10 per year, although it amounts to $28 for some "sleeping sections." Mr. Arnold assumes an annual earning of $12 per capita in the district served by a possible subway. This makes it necessary that the system should serve 150,000 people—in addition to those yielding present surface-system traffic. The maximum density of population in Pittsburg, over any considerable areas, is about 100 per acre, though in the old Seventh Ward it mounts to nearly 200, while in some residence sections it is not over 30. In the "Harlem" section of New York City, the best contributing district of the subways there, the density of population is 150. Mr. Arnold points out that with Pittsburg's opportunities for expansion extended areas of large apartment houses become improbable there, and that a density of only 50 per acre can safely be assumed for the territory which any subway line would tap. The 150,000 patrons of the subway, then, would occupy some four or five square miles and it is argued that such a territory can profitably be served only by a combined surface and subway system, one in which the subway serves as a main trunk and the surface lines as collectors and distributors. It is also suggested that success cannot be assured unless the subway is located so as to accommodate suburban passengers coming in on present railway lines, bearing in mind the possibility of furnishing these roads a down-town terminal for their trains in the event of their substituting electric traction for steam.

The first section of subway is expected to be needed to connect the business (down-town) section with, the so-called, "East Liberty"; the second line should be built under the Allegheny River to Allegheny; the third would be a loop around the business district and the fourth an extension to the "South Side."

The financial burdens are estimated as follows:

(1) Operating Expenses, including taxes, damage, insurance and maintenance, 40 to 60% gross earnings.
(2) Annual Depreciation Fund, 3 to 5% of the cost of equipment.
(3) Amortization Fund, 1% of cost of construction (compounded at 2½%) to retire the investment in structure in 50 years; alternative rate of ⅛% to retire the investment in 75 years.
(4) A Contingent Reserve Fund to care for extraordinary accidents, etc., to accumulate and to be invested until it reaches 5% of the total cost of the system.
(5) Interest on Cost, varying from 4% (with municipal credit) to 8% (with private capital).
(6) Discount Fund, to offset the discount on bonds in some 20 years.
(7) Surplus Profits, in the case of private ownership to be divided with the city on some equitable basis or used for extensions.

It is Mr. Arnold's expressed belief that a subway should pay in Pittsburg eventually, but that there will be a loss during the first years of operation. Such a deficit must be paid out of subsequent earnings so that too long a time should not elapse between the opening and this turning point. That is, it must not be built upon too large a scale or too soon and not unless definite arrangements are made with existing transportation systems for the joint use of the subway to the mutual advantage of the public and the systems.

For ascertaining, still more definitely, the prospects of building the subway in advance of actual needs, so that it may influence the growth of the city, Mr. Arnold proposes seven lines of investigation: (1) into the best terms which private capital will offer for building, equipping and operating a subway; (2) into the legislation necessary for the city to issue self-supporting bonds for purchasing, constructing or equipping the subway in order to reduce fixed charges; (3) into interchanging transfers with street railways; (4) into how the growth of sections may be influenced; (5) into increase in values of real estate in the districts to be served and the consequent probability of sufficient apartment houses to yield a favorably density of population; (6) into the possibilities of raising the first cost of a subway by assessments on real estate benefited.

The Standardizing of Street Railway Track Construction in Paved Streets.*

By B. E. TILTON.†

A large majority of roads find themselves afflicted with the maintenance of from 25 to 75 different types of construction on their city lines. At certain times in their history it becomes necessary for them to make heavy track renewals, and to choose a type of construction which is the most efficient and at the same time the most economical to build and maintain.

It is very difficult to decide between the various types of construction which have been put down in the past 20 years. Each shows some point of superiority over the others. The natural result, therefore, is to build an experimental piece of track embodying as many of the good points of the old types as possible and from the results shown by this construction derive conclusions for our standard type.

Such a section of track was built in Rochester in 1909. A good system of drainage was put in, 7½-in. concrete ballast, steel ties, T-rail and stone block pavement. The rail was laid of three kinds (Bessemer, open-hearth and nickel-steel), held with Continuous plates. The pavement was Medina block set on a mortar cushion instead of sand. The stones were 5 ins. deep and the groove was cut in them by hand. This is being used as the basis of an analysis of a track structure.

The constituent parts of the track structure in paved streets are (1) the foundation; (2) the substructure, and (3) the superstructure.

FOUNDATION.—The foundation of our track is ordinarily clay or sandy soil. It is the bottom of a trench 15 to 21 ins. below the surface of the street, and is, therefore, a natural sump for the collection of surface water. The first standard to perfect is the drainage system, because an accumulation of confined water in this trench will destroy the best substructure and superstructure which can be built. One standard which can be used with success consists in giving the bottom of the trench a 6-in. crown at the center so as to form a natural path for the water to flow to the outside of each track. Outside of each outside rail and 12 ins. below subgrade place a 4-in. sewer-pipe drain carefully lined and having the joints wrapped with burlap. In this way the water is drained away from the center.

Various schemes have been used for compacting the foundation. In some cases it is rolled; in other cases crushed stone is tamped into the ground to produce an arching effect in the soil. This is a condition which cannot be standardized, as it depends on the nature of the soil.

SUBSTRUCTURE.—This consists of the ballast and ties. For ballast, sand, crushed stone, gravel and concrete will make a good substructure; the sand least of all on account of its tendency to wash under the action of water.

Concrete will not stand up unless allowed time to take its final set before traffic is allowed to pass over it. This time should not be less than 10 days. There are certain conditions of city operation which will not permit an interruption of 10 days, and this gives rise to the use of a material such as crushed stone for ballast. When conditions are such that we can absolutely close the street to all traffic for a period of 10 days I believe the rigid concrete ballast should be standard construction.‡

The depth of the ballast depends on the amount of traffic and the character of the foundation. A depth of 6 ins. below the bottom of the tie for concrete and 8 ins. for stone ballast substructure is reasonable for standard construction.

We have available two kinds of ties, wood and steel, but the tendency is to eliminate the wood tie, due to the increasing cost and scarcity of timber. With a concrete substructure, the ties (which form the other element of the substructure) must be as long-lived as possible. The steel tie, therefore, goes hand in hand with concrete ballast. The weight of the tie depends on the engineer's judgment. Its requirements are bearing area, stiffness and accurate rolling.

While the concrete foundation and steel tie construction gives the highest type of standard substructure, one weakness arises from the difficulty of renewal. The present form of steel tie cannot be taken out without heavy labor cost and the possibility of destroying the concrete substructure. New rail cannot be laid on the old ties and put in surface except by shimming. If our concrete substructure is going to outlive the rail, joints and pavements we must find a way to renew the steel tie. This will mean either the use in the first installation of a wood tie or of a steel tie of different shape than those now on the market. If, for instance, we used a wood tie in the concrete in the original construction these could be removed and a small steel tie in[illegible]d in the cavity when the rail renewal took place, thu[illegible]ving twice the life to the substructure as to the su[illegible]ructure.* The same thing would be true of a d[illegible]ently shaped steel tie. I think this condition must be [illegible] be-fore we can call our concrete-steel tie type con-struction really standard.

For our second or stone-ballast type of sub[illegible]cture construction only the wood tie can be used, as steel tie in stone ballast requires constant maintenan[illegible]or a year after installation. In paved streets we a[illegible] com-pelled to close up the pavement as soon as poss[illegible] and consequently could not undertake frequently to [illegible]amp for a year the steel ties in stone ballast.

SUPERSTRUCTURE.—This consists of the rail, joints and pavement. In a way this is the least im[illegible]rtant part, as its life depends to a large extent on th[illegible] foun-dation and substructure. Stability in our subs[illegible]cture produces stability in the rail and consequently a [illegible]nger life to our pavement.

The choice of a rail is a discouraging undertak[illegible]. We have no great trouble in keeping our rail in surf[illegible], but it is difficult to keep our rail in line. This is du[illegible] to the fact that we operate single cars and do not h[illegible] the steadying effect of a long train as on steam roads. This fact fixes our standard rail as one whose physical prop-erties tend to make it easy to keep its alinemen[illegible]. The first requirement in a rail to meet this condition [illegible] that it be center-bearing and under present designs thi[illegible] limits us to a T-rail. As far as I know, no center-bearing groove rail has yet been rolled.

Theoretically, I think it can be shown that an 80-lb T-rail will meet any service, including interurban ser-vice, which is met in city work. However, the first cost of the rail represents only about 10% of the net cost of a track, so there is no great object in picking light rails within reasonable limits. The character of pavement must decide our type of T-rail, whether standard or special. For cities whose specifications call for a 7-in. stone for stone block pavement, the special T-rail, as recommended by the American Street & Interurban Rail-way Association, meets the requirements. With brick pavement the Am. Soc. C. E. T-rail section can be successfully installed.

The wood block pavement is coming into general use, and will force us to have another standard superstruc-ture. As it is not practical to cut a groove in the wood block and maintain it, our third standard for super-structure should call for a groove rail.

Types of joints and fastenings are nearly as numer-ous as types of rail. Two ideas present themselves in the joint problem. Are we going to construct a joint designed to be permanent or a joint which permits main-tenance? As the standards outlined above are designed to permit maintenance, our joint standard to be in conformity must be a joint which can be maintained. The riveted joint as recently developed fulfills the me-chanical requirements of a joint and also permits main-tenance. The only objection is the high cost of the riveting outfit, which makes it prohibitive to some roads. As a mechanical joint its results are more than was ex-pected.

To those who cannot afford this riveted joint, any of the base-supported joints give a joint susceptible of maintenance and form a fair standard for our construc-tion. The bolts are hard to tighten, but if necessary this can be done. The surface of the rail can be kept true at the joints by the use of a special cutting flat file. The idea proposed by the Boston Elevated Ry. in 1890 of in-stalling a joint box adjacent to the joint to allow the tightening of the bolts was a good one. This idea has been experimented with recently, but no practical re-sults have been developed.

The choice of rail as between Bessemer, open-hearth and alloy cannot as yet be based on experience. No great superiority has been shown for open-hearth steel over Bessemer. The alloy rails, such as nickel, have shown about 20% greater resistance to abrasion than the Bes-semer, but are prohibitive on account of the high cost. Titanium rail has shown remarkable results on the New York Central Ry. The application of the titanium does not greatly increase the cost of the rail and, therefore, an ordinary street railway can afford to experiment with it. Extensive experiments are being carried on in the comparison of the wearing qualities of Bessemer, open-hearth and alloy rail, but the method of rolling seems to have the greatest effect on the wearing quality of the rail.

For the frogs, switches and mates we have four types of construction to choose from: Solid manganese work; cast-steel construction with hard center plates; iron-bound construction with hard center plates, and ordinarily built-up work. These types of construction are stand-ard, and it remains for the railways to standardize them as to location and as to radii of switch pieces to permit renewals without the expense of new patterns.

Drainage of the special work foundation is even of more importance than in standard track construction.

*Abstract of a paper read at the annual meeting of the Street Railway Association of the State of New York, at Cooperstown, N. Y., June 28, 29, 1910.

†Engineer of Maintenance of Way, New York State Railways Co., Rochester, N. Y.

‡In many cases it would be practicable to close only one side of the street at a time, or to exclude traffic only from the central portion occupied by the track or tracks.—Ed.

*On the other hand it might be difficult to so bond the new concrete around the steel tie (in the recess left by removing the wooden tie) to the concrete of the substructure as to ensure a solid and substantial construction.—Ed.

Since steel ties are not practicable in connection with special work installations, we must use the wood tie. Here is a chance to standardize by making up special sets of ties to fit each turnout. In this way we have a direct result of standardization by saving a very considerable amount by not using the ordinary tie and overlapping the ends.

Stone ballast probably meets the greatest number of requirements in connection with the special work substructure. It allows water to pass through it, and does away with the allowance of 10 days for setting, as would be required with concrete substructure. Crushed stone also permits surfacing when renewals are made.

The choice of the third part of our superstructure, the pavement, is not entirely in the hands of the railway. Pavement is essentially a problem for the city engineer, and our superstructure standards must be such as meet his requirements as to pavement. My experience has been that city engineers will not permit the use of brick on any except light-traffic streets, and the tendency is more and more toward the use of the stone block pavement. This is to our advantage, as the block stone has a high salvage value, while other classes of pavement have little or none. After the choice of pavement has been made, the company can have something to say as to the method of laying the pavement.

One of the direct results of the experimental piece of track built in Rochester was a change in the pavement specifications abolishing the use of a sand cushion and substituting for it a dry-mortar cushion. The cushion consists of 1:1 dry mortar. When the grouting takes place, the water from the grout sets the dry-mortar cushion so that the blocks are on a solid bed, instead of a sand bed easily washed by water. This requirement should be added to ordinary paving specifications and made a standard form of paving construction.*

GENERAL STANDARDS.—We have then the following general standards which may be applicable to cities of ordinary size:

Foundation.—The foundation should be well drained in any type of construction.

Substructure.—(1) Six-inch concrete substructure laid where it is possible to keep all traffic off the street for a period of 10 days after the concrete is placed; (2) 8 ins. of stone ballast to be used where it is not possible to keep all traffic off the street for 10 days.

Superstructure.—(1) Special 7-in. T-rail as recommended by the American Street & Interurban Railway Association where the pavement is to be stone block; (2) Am. Soc. C. E. section of T-rail where the pavement is to be brick; (3) grooved rail where the pavement is to be wood block.

The choice of the three rail standards as above has left out one consideration important in some cities, which is width of street. It can readily be seen that where all traffic is compelled to take the car tracks this fact might so far outweigh the advantages of T-rail as to make inadvisable its use as against a groove rail.

In addition to the standards outlined above, there are many details, such as tie treatment, fastenings, tie-rods, tie-plates, bolts, etc., which can be standardized. These, while important, are not the controlling factors in a track structure. The important requirement for these details is that we stick to one standard so as to make renewals easy and inexpensive.

Local conditions have a very great effect on our type of standard construction. Whenever sewer systems are rebuilt the tracks must come out and be rebuilt. Another point tending to reduce the life of a track is the continual construction of laterals of all sorts beneath the track. Sewer laterals, fire-alarm conduits, electric light conduits, water mains, gas mains and various other forms of municipal utilities find occasion frequently to cross the street and consequently have to undermine the track. In each case where this is done the so-called permanent track is reduced to limited life track.

LIGHTNING CAUSED THE EXPLOSION of the drying house of the Du Pont De Nemours Powder Works, at Pompton, N. J., on July 28. The explosion occurred in the early morning and no one was injured. The drying house was five stories in height and was used for drying gun cotton after the fiber had been impregnated with nitroglycerine.

A STREET CAR BROKE THROUGH A BRIDGE over the Rio Grande at El Paso, Tex., on July 29. The river was not deep and none of the 25 passengers were injured seriously. The bridge was a wooden one, built in 1901, and has lately become noted as the meeting place of President Taft and President Diaz of Mexico last October.

THE COLLAPSE OF A CONCRETE ROOF over a coal shed, in the course of construction for the Montreal Light, Heat & Power Co.'s plant, at Montreal, Que., caused the death of one workman and injured nine others on July 23. The building was almost entirely of reinforced concrete and nearly completed. No cause for the accident has yet been assigned.

A GRADE CROSSING ACCIDENT at Cleveland, Ohio, on July 27, injured 16 passengers on a St. Clair Ave. street car and demolished the car. The accident occurred at the point where St. Clair Ave. crosses four tracks of the Pennsylvania R. R., and is the same at which a similar accident took place in August, 1905.

A SEVERE WINDSTORM on the night of July 25, wrecked seven aeroplanes at Washington Park, Ill. The aeroplanes were housed under a circus tent which collapsed during the storm. The damage to the machines is estimated at $25,000.

A BUTTING COLLISION of two freight trains on the Norfolk & Western Ry. caused the deaths of two trainmen on July 26. The accident happened on the New River Division, about 50 miles west of Roanoke, Va.

THE DERAILMENT OF A PASSENGER COACH on the Chesapeake & Ohio Ry., near Charleston, W. Va., killed one person and injured two others on July 26. All the persons injured were riding on the platform of the car, which became derailed in backing on a siding, causing it to fall over an embankment.

A LARGE ROCK ON THE TRACK overturned the locomotive of the fast New York express on the Baltimore & Ohio R. R., near Parkersburg, W. Va., on July 31. The train was running at a rate of about 40 miles an hour and the locomotive after overturning rolled down a high embankment, seriously injuring the engineer and fireman, who had remained at their posts. Five coaches composing the train did not leave the rails and no passenger was injured. The rock is supposed to have rolled on the track accidentally.

AN AERIAL VOYAGE FROM NEW YORK TO LONDON is now planned by Messrs. Melvin Vanaman and Walter Wellman in the dirigible balloon "America." Mr. Vanaman arrived in New York on July 31, and is reported to have set the date for leaving in the "America" as Aug. 20. The balloon is also to carry two mechanics and one other passenger. The outfit includes a non-sinkable lifeboat 25 ft. long, and will be stored with provisions for 30 days.

THE BEST EXHIBIT OF MACHINERY for pumping underground waters is to be awarded a prize at the International Irrigation Exposition to be held at Pueblo, Colo., Sept. 19 to Oct. 1, 1910, in connection with the Eighteenth National Irrigation Congress. The prize is to be a silver loving cup, and is offered by "The Irrigation Age of Chicago." Mr. L. M. Markham, of Pueblo, is Director of Exhibits, and Mr. Arthur Hooker, also of Pueblo, is Secretary of the Congress.

THE NATIONAL LAND AND IRRIGATION EXPOSITION is to be held at Pittsburg, Pa., Oct. 17-29, 1910, under the joint auspices of the "Gazette Times" and "Chronicle Telegraph" of that city. Mr. Sidney Wire is Director of Publicity. Exhibits are expected from the United States Government, various states, land and irrigation companies, boards of trade, etc. Land reclamation and irrigation will be features.

A FIRE IN THE U. S. GEOLOGICAL SURVEY Building at Washington, D. C., threatened for the fifth time to destroy the valuable records and library of the Survey. We give below a memorandum regarding the fire, prepared by Mr. George Otis Smith, Director U. S. Geological Survey, Washington, D. C.:

The fire which occurred this afternoon (Aug. 1) in the Geological Survey building originated and was largely confined to the first floor of the building, occupied by other tenants. It gives emphasis, however, to the wisdom of Congress in authorizing at its last session the preparation of plans for a government building that will not only be better adapted to the peculiar needs of this scientific and map-making bureau, but will insure the safety of the public records that have been five times endangered by fire destruction since 1903.

The fire of to-day originated in one of the several stores, over which the Survey watch force have no control, but in a few moments the flames had burst through into the Survey library, situated directly above. The loss of government property is thought to be less than $1,000, but an incalculable loss might easily have been incurred in this library which is unique in its collection of geologic literature, containing as it does more than 65,000 volumes as well as 85,000 pamphlets and 35,000 maps and constituting the most complete collection of geological works and maps in this country if not in the world. The destruction of these by fire would have deprived not only the geologists of the Survey but the scientists of America of a reference collection that could not be duplicated. Indeed in spite of the quick response of the Fire Department, if the watch force and some of the members of the Survey who were in the building had not promptly used hand extinguishers the damage to books and maps must have been considerable.

A SECOND HIGH-PRESSURE FIRE-SERVICE pumping station has been completed in Philadelphia. This is located at Seventh St. and Lehigh Ave. and will be known as the "Fairhill Station." The station already in use is at Delaware Ave. and Race St., and was designed merely to protect the central business district, while the new one will supply high-pressure fire lines in the Kensington mill district. The combined capacity of these stations is 35,000,000 gals. per 24 hrs., at 300 lbs. gage pressure (at the station). The new plant has ten pumping units, each consisting of a three-cylinder, four-cycle, 300-HP. gas engine driving a piston pump rated to deliver 12,500 gals. per min. These units are arranged in two distinct divisions; the five units on one side of the station can discharge entirely separate from the five on the other side. The station will receive every alarm of fire for the district served and immediately on receipt of an alarm one unit will be started; other units are to be started as needed. Only three minutes is required to place full load on each unit.

A MONUMENT TO AN ENGINEER is somewhat of a rarity, yet there was recently unveiled in New York City a handsome memorial to a justly famed engineer. The ceremonies accompanying the official opening of the new Manhattan terminal of the Pennsylvania Lines, included the unveiling of a bronze statue of the late A. J. Cassatt, President of the Pennsylvania R. R., 1899-1906. The following inscription is upon the base of the monument:

ALEXANDER JOHNSTON CASSATT,
President, Pennsylvania Railroad Company
1899 1906
WHOSE FORESIGHT, COURAGE AND ABILITY
ACHIEVED THE EXTENSION OF THE
PENNSYLVANIA RAILROAD SYSTEM
INTO NEW YORK CITY.

TESTS ON A FLEXIBLE SEWER-PIPE JOINT COMPOUND, to determine its effectiveness in keeping sewage in and ground water out of the pipe, were recently made by Mr. W. W. Dixon for Mr. John S. Stiger, City Engineer of Summit, N. J. The compound is a plastic, rubber-like mixture patented by the Union Clay Products Co., New York City. In its application it is first melted and poured around a stiffening wire into a narrow form so as to make a rope-like gasket which can be packed into the joint in the same manner as the ordinary rope gasket is generally applied. It can then be gone over with a torch and made to adhere to the edges of the pipe.

The first test was upon 300 ft. of 10-in. vitrified pipe laid under service conditions on a 0.6% grade, in a new sewer in Summit, N. J. The ends of the section were closed up and the trench allowed to fill with water. After 12 days of rainy weather, there was 7 ft. of water in the trench, and a gage at the lower end of the pipe showed only 300 gals. infiltration of water in the pipe after standing for two days. The second test was on 300 ft. of 10-in. pipe, which after having 2 ft. of water above it for one week showed no infiltration whatever. In addition to the above tests, which were upon pipe laid by contractors under a guarantee specification, a laboratory test was also made. In this test two 3-ft. lengths of 10-in. vitrified clay pipe were joined together with the patent joint compound and plugged at each end. A pressure of 22 lbs. per sq. in. was then applied to the interior without any leakage appearing at the joint. The pipe was then set up on two end supports and a deflection of 1¾ ins. given to the middle (at the joint). The pressure under this condition again reached 22 lbs. without any leakage showing at the joint but at that pressure the end plugs blew out.

A DAM 70 METERS (229.7 ft.) high and 250 m. (720 ft.) long, and a subsidiary dam about 74 ft. high and 2,394 ft. long, form essential parts of the 40,000-HP. Conchos River hydro-electric plant, now under construction near Santa Rosalia, Chihuahua, Mex., for the Compania Agricolo de Fuerza Electrica del Rio Conchos. The work on the dam involves the following approximate quantities: 96,000 cu. yds. of earth excavation, 360,000 cu. yds. of rock excavation, 107,000 cu. yds. of concrete masonry, 357,000 cu. yds. of stone masonry, 183,000 cu. yds. of fill, and nearly 150 acres of clearing work. Of the 360,000 cu. yds. of rock excavation no less than 260,000 cu. yds. will be for the spillway, which will have a length of 60m. (197 ft.). The contract includes some 200 miles of steel-tower transmission line, besides administration offices and houses for staff and men, power station, etc., and some 22 miles of standard railway—the latter extending from Santa Rosalia to the new town of La Boquilla, at the site of the dam. The contractor for all the work indicated is S. Pearson & Son, Successores, S. A., 4 a Calla de Humboldt 31, Mexico, D. F. For the foregoing information we are indebted to Mr. F. W. Adams, Managing Director of the concern just named.

GRADE REDUCTIONS on some parts of the Cape Government Railways, South Africa, are becoming necessary on account of the heavy grades originally adopted and the increase of traffic within recent years. In the original construction through certain districts of very heavy country maximum grades of 2½% were adopted. The present policy is to reduce these to 1½% to avoid the necessity of splitting the trains or using helper engines, but on some sections the cost of such

*In Chicago, a mortar cushion (of the same material as that used for filling against the rail webs) is required for the paving blocks laid directly against rails of the T-girder or tram-head girder section. The intermediate blocks are laid on the usual sand cushion.—Ed.

reduction is almost prohibitive. The railways are owned and operated by the government, and last year some of the reduction work was begun with day labor, in order to provide relief work for unemployed Europeans. The results were not satisfactory; there was a strike among the men, and they were transferred to the grading of a new extension, while the grade reduction work was placed in the hands of contractors. The main line from Cape Town to Pretoria has maximum grades of 1½% except on one division where the old 2½% grades remain. On one part of this, over the mountain summit, the work would be so expensive that the interest on the cost would be greater than the expense for helper engines. On another part, the heavy grade is at present in the direction of the heavier traffic, and will not require reduction for some years. On the remaining 78 miles, the trains have to be reduced to about half their normal weight. Mr. T. S. McEwen, General Manager, in his report for 1909, has recommended that the reduction to a compensated grade of 1½% should be taken in hand at once, at an estimated cost of $1,110,000. Its completion would effect a very considerable reduction in operating expenses (after paying interest charges) even with the present traffic. The manager states, however, that with the union of the African colonies, a very heavy passenger traffic will be created between the legislative and executive capitals of South Africa (Pretoria and Cape Town) and the question of shortening the time between these points will be of great importance.

AN INCREASE IN THE CAPACITY OF THE PITTSburg Water Filtration Plant without enlarging the works is held to be possible by Mr. George A. Johnson, Assoc. M. Am. Soc. C. E., of Hering & Fuller, New York City. The plant now consists of 46 acres of sand filter beds in use and there are 10 additional acres of beds approaching completion. Mr. Johnson states in an official report to the city authorities of Pittsburg that by changes in the method of operating the filters their capacity might be increased to a total of 200,000,000 gals. per day, and possibly 225,000,000. The report is a preliminary one, and therefore full details have not been worked out. The essential steps in the process are stated by Mr. Johnson in the report as follows:

(1) Improve the facilities for sterilizing the filtered water and adjust the hypochlorite treatment at all times so that the hygienic quality of the filtered water delivered to the consumers will be satisfactorily maintained, regardless of the rate of filtration.
(2) Put the filters into service at full normal rate immediately after cleaning.
(3) Reduce to a minimum the frequency of scraping the filters and take full advantage of other means of relieving clogging, especially by raking the sand surfaces or by using the Brooklyn method of cleaning, or a combination of the two.
(4) Investigate the excessive cost per cubic yard of sand handling.
(5) Provide facilities for the application of a coagulant to the river water at times when additional clarification beyond that afforded by the present reservoirs is required for the advantageous operation of the filters.
(6) Provide baffles in the present sedimentation reservoirs so as to secure a more complete displacement of the water during its passage through the reservoirs, and thus secure more efficient sedimentation.
(7) Investigate means for correcting iron and acid conditions in the river water due to mine drainage.
(8) Increase the capacity of the low-lift pumping equipment as required.

A SUBMARINE TELEPHONE CABLE, equipped with Pupin loading coils (Eng. News, Aug. 23, 1900, p. 133) has been laid across the English Channel between Dover and Cape Gris Nez, to improve telephone service between England and France. Tests were carried on in July by Major W. A. J. O'Meara, Chief Engineer of The Post Office, and are reported in the London "Electrician" July 22. It appears that the new cable is exactly like the old one it parallels except for the Pupin coils. In testing, comparisons were made of the old and new cables by adding on (at shore station) of lengths of standard cable until speech became uncommercial. The new cable (average found by several operators) could be connected to 17 miles of standard cable line more than could the old cable. This is stated to be a gain of 450 miles of land lines. A marked improvement in clearness of speech was also reported. This cable, about 22 miles long, was laid somewhat as an experiment, no such "loaded" cable of great length having been laid.

A COMPETITIVE EXHIBITION OF FENCING MAterials is to be held by the Middleburg Agricultural Society, of Middleburg, Cape Colony, Africa, in March, 1911, in connection with the Annual Agricultural Show of that organization. We are informed by Mr. J. S. Minnaar, Honorary Secretary, of the Society, that prizes to the amount of £26 are offered. Mr. Minnaar adds:

In order to afford the makers in America an opportunity of joining in the competition, which will be an excellent advertisement for their goods, I shall esteem it a favor if you would give publicity to the exhibition in the columns of your paper. Prize lists will be ready for issue by July 15, 1910, and may be had from me.

THE DISCHARGE OF PULP WASTES INTO KAYderosseras Creek and Saratoga Lake, N. Y., has been enjoined by a judge of the State Supreme Court in a suit brought against the Union Bag & Paper Co. An individual complainant has been awarded damages to the amount of $312 per year for a term of four years. A campaign against the pollution of these waters began in 1899 when riparian owners petitioned the Governor, who was then Theodore Roosevelt, to take action to stop the pollution.

Personals.

Mr. W. M. Vigal has been appointed Terminal Engineer, in charge of construction at Tampico, Mex., for the National Rys. of Mexico.

Mr. F. L. Thompson, formerly Assistant Engineer of Bridges, has been made Engineer of Bridges and Buildings of the Illinois Central R. R., at Chicago, Ill.

Mr. G. E. Ellis, M. Am. Soc. C. E., formerly with the Hayes Track Appliance Co., has been appointed Signal Engineer of the Kansas City Terminal at Kansas City, Mo.

Mr. Frank C. Kelsey, formerly Consulting Engineer for the municipal hydro-electric plant of the city of Tacoma, Wash., has entered into a general consulting practice in that city.

Mr. M. H. Godfrey has been appointed Superintendent of the Oliver Iron Mining Co.'s mines in the Canisteo district of the Missabe range. Mr. Godfrey formerly had charge of the Chisholm district.

Mr. John C. Sheridan, Chief Engineer of the Department of Highways, Borough of Brooklyn, New York City, has resigned to become Chief Engineer and General Manager of the Cranford Contracting Co.

Mr. Mortimer D. Metcalfe, of Ossining, N. Y., has been appointed Deputy State Architect of New York, succeeding Mr. M. F. Oliver, resigned. Mr. Metcalfe is a graduate of Pratt Institute School of Architecture.

Mr. Russell Suter, Assoc. M. Am. Soc. C. E., has resigned his position as Assistant Engineer, Board of Water Supply of the City of New York, to accept a position with the New York State Water Supply Commission.

Mr. John C. Rennard, Assoc. Am. Inst. E. E., has been appointed Electrical Engineer of the New York City Fire Department at a salary of $5,000. Mr. Rennard is a graduate of West Point Military Academy and of Columbia University.

Mr. Stephen William White, Secretary of the Northern Central Ry. Co., and various other subsidiary companies of the Pennsylvania R. R. System, was retired, having reached the age limit, on Aug. 1, after more than 35 years of continuous service with the Pennsylvania Lines.

Mr. Moses Burpee, M. Am. Soc. C. E., Chief Engineer of the Bangor & Aroostook R. R., has been appointed Consulting Engineer. Although he will still be designated by the title of Chief Engineer, the duties hitherto connected with that office will devolve upon Mr. P. C. Newbegin, Assoc. M. Am. Soc. C. E., who has been appointed Maintenance Engineer.

Mr. George Westinghouse, President Am. Soc. C. E., inventor, and organizer of many corporations in this country and abroad, which bear his name, has been succeeded as President of the Westinghouse Electric & Manufacturing Co. by Mr. Edwin F. Aikens, of Boston, Mass., representing the banking interests which have controlled this company since its receivership in 1907.

Mr. E. T. Archer, of Archer, Rollins & Co., Consulting Engineers, of Kansas City, Mo., has severed his connection with that firm and opened an office as a consulting engineer, at 426-27 Beals Bldg., Kansas City, Mo.

Mr. W. B. Rollins and Mr. H. C. Westover, of the firm Archer, Rollins & Co., have formed a new firm to be known as Rollins & Westover, Consulting Engineers, with offices at 534-35 Beals Bldg., Kansas City, Mo.

Col. William M. Black, M. Am. Soc. C. E., of New York City, Lieut.-Col. Mason M. Patrick, M. Am. Soc. C. E., of Norfolk, Va., and Capt. Harley B. Ferguson, of Montgomery, Ala., of the Engineer Corps, U. S. A., have been appointed by Acting Secretary of War Oliver, a board to devise and consider plans for raising the battleship "Maine," in Havana Harbor. Col. Black was Chief Engineer of the Department of Havana, 1899-1900, during the military intervention.

Obituary.

Gen. W. H. Lessig, veteran of the civil war and Territorial Surveyor-General of Colorado in the '60s, died on July 26 at Mone Vista, Colo.

Robert Ewing Anthony, a civil engineer of New York City, died at his home on July 28. He had been associated with several contracting companies and was one of the oldest transit inspectors of the Public Service Commission.

Jefferson Davis Bradford, a civil engineer, died in New Orleans, La., on July 31, at the age of 75 years. He was educated at West Point Military Academy and previous to the civil war was an officer of the U. S. Coast Survey. He was a nephew of Jefferson Davis, President of the Confederacy, and fought on the Southern side during the war. He was Assistant Engineer in laying out Central Park, New Orleans, and was re-employed by the government at Fort Moultrie, Charleston Harbor, S. C.

William Van Vleck Lidgerwood, London representative of the Lidgerwood Manufacturing Co., died in that city on July 27, after an illness of several months. Mr. Lidgerwood was 78 years old and a brother of the late John H. Lidgerwood, Treasurer of the Lidgerwood Manufacturing Co., of New York City. These two brothers in charge of the Speedwell Iron Works, Morristown, N. J., built the boiler of the "Savannah," one of the earliest trans-Atlantic steamers. They also manufactured the tires, axles and cranks of some of the earliest American locomotives.

Hylas Sabine, formerly a railroad commissioner of Ohio, died on July 24, at his home in Cambridge, Mass. Mr. Sabine was 81 years old, a native of Ohio and father of Prof. Wallace C. Sabine, Dean of the Lawrence Scientific School of Harvard University. He was a railroad commissioner of Ohio 1881-1885 and is said to have been the first man in his state, and among the first in this country, to establish and enforce state supervision over, and compulsory reports from, railway corporations. After his service on the railroad commission he continued to take an active interest in railway affairs, more especially as an advocate of the compulsory adoption of safety devices. For the last 15 years he had made his home in Cambridge. He was a graduate of Harvard Law School, Class of 1864.

Engineering Societies.

COMING MEETINGS.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 16-19. Annual convention at Niagara Falls, Canada. Secy., W. O. Thompson, New York Central Car Shops, East Buffalo, N. Y.

LEAGUE OF AMERICAN MUNICIPALITIES.
Aug. 23-26. Annual convention at St. Paul, Minn. Secy., John MacVicar, Des Moines, Iowa.

LAKE SUPERIOR MINING INSTITUTE.
Aug. 24-26. Annual meeting at Ironwood, Mich., and Chicago, Ill. Secy., A. J. Yungbluth, Ishpeming, Mich.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Sept. 5-9. Annual meeting at Milwaukee, Wis. Secy., W. C. Woodward, Washington, D. C.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES.
Sept. 6-8. Annual meeting at Thousand Islands, N. Y. Asst. Secy., Walter Neumuller, 55 Duane St., New York City.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Sept. 6-9. Annual convention at Rochester, N. Y. Secy., Frank P. Foster, Corning, N. Y.

MICHIGAN GAS ASSOCIATION.
Sept. 8-12. Annual meeting on board steamer sailing from Detroit, Mich. Secy., Glenn R Chamberlain, Grand Rapids Gas Light Co., Grand Rapids, Mich.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 13-16. Annual convention at St. Louis, Mo. Secy., A. P. Dane, Reading, Mass.

ROADMASTERS AND MAINTENANCE-OF-WAY ASSOCIATION.
Sept. 13-16. Annual convention at Chicago, Ill. Secy., Walter E. Emery, Chief Engineer, Peoria & Pekin Union Ry., Peoria, Ill.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION.
Sept. 21-23. Annual convention at Colorado Springs. Secy., J. C. Lawler, P. O. Box 938, Colorado Springs.

NEW ENGLAND WATER-WORKS ASSOCIATION
Sept. 21-23. Annual convention at Rochester, N. Y. Secy., Willard Kent, Narragansett Pier, R. I.

NATIONAL IRRIGATION CONGRESS.
Sept. 26-30. Annual meeting at Pueblo, Colo., Secy., Arthur Hooker, Pueblo, Colo.

CHICAGO IRRIGATION ASSOCIATION.—This association was organized recently for the purpose of encouraging land reclamation and development, and its first regular meeting was held at the La Salle Hotel on July 28. Addresses were made by several speakers, including H. L. Moody, of the National Irrigation Congress, and E. T. Perkins, of the local bureau of the U. S. Reclamation Service. It was decided to invite the National Irrigation Congress to hold its 1911 meeting in Chicago. The President of the new association is Edmund T. Perkins, Federal Bldg., Chicago, Ill.; the Secretary, C. A. Morrison.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.—The fourth annual convention of this society will be held in Boston, Mass., Nov. 17-19. An item of particular interest in connection with this meeting is the announced address by Dr. Georg Kerschensteiner, Superintendent of Schools, Munich, Bavaria, on "Continuation Schools." Separate sessions will be devoted to the following topics: "Part Time and Evening Schools," "Apprentice and Corporation Schools," and "The Broader Aspects of Industrial Education." The Secretary of the society is James C. Monaghan, 20 West 44th St., New York City.